Indian Science Congress Association

TWENTY-EIGHTH ANNUAL MEETING

January 2nd, 3rd, 4th, 5th, 6th, 7th and 8th, 1941

to be held at the

Arts College Hall and University Colleges, Benares

PROGRAMME
(Provisional)

CALCUTTA
Indian Science Congress Association,
92, Upper Circular Road.

IMPORTANT NOTICE

This programme is only provisional. A revised and detailed programme including the list of local excursions, social functions, and entertainments will be issued to members on Wednesday, January 1st, 1941, from the Local Secretaries' Office.

The abstracts of papers, as far as available, to be read at the Discussions will be issued at the same time.

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Rai Bahadur K. N. Bagchi	*Sectional Correspondent.*
Mr. B. A. Pathak ..	*Local Sectional Secretary.*
Dr. G. D. Bhalerao .. Dr. A. Lakshmanaswami Mudaliar ..	*Elected Members.*
Lt.-Col. S. S. Sokhey .. Lt.-Col. K. R. K. Iyengar Bt.-Col. R. N. Chopra .. Sir U. N. Brahmachari Rao Bahadur T. S. Tirumurti .. .. Mr. J. R. Haddow ..	*Past Presidents who are Ordinary or Honorary Members.*
Dr. M. B. Soparkar .. Mr. A. C. Ukil .. Rao Bahadur T. S. Tirumurti .. .. Prof. S. W. Hardikar .. Capt. S. Datta .. Dr. Phanindranath Brahmachari .. Dr. C. G. Pandit ..	*Past Recorders who are Ordinary or Honorary Members.*

11. Agriculture—

Mr. K. Ramiah ..	*Convener.*
Dr. C. N. Acharya ..	*Recorder.*
Dr. R. P. Mitra ..	*Sectional Correspondent.*
Prof. K. Kumar ..	*Local Sectional Secretary.*
Dr. Nazir Ahmad .. Dr. H. S. Pruthi ..	*Elected Members.*
Rao Bahadur M. R. Ramaswami Sivan .. Rao Bahadur T. S. Venkatraman .. Sir T. Vijayaraghavacharya .. .. Rao Bahadur G. N. Rangaswami Ayyangar Mr. M. Azfal Husain .. Mr. A. K. Y. Narayan Aiyer .. .. Rao Bahadur B. Viswanath .. .. Rao Sahib T. V. Ramakrishna Ayyar .. Rai Sahib Jai Chand Luthra	*Past Presidents who are Ordinary or Honorary Members.*

Mr. N. V. Joshi ..	*Past Recorders who are Ordinary or Honorary Members.*
Rao Bahadur B. Viswanath	
Dr. S. V. Desai ..	
Mr. Y. D. Wad ..	
Dr. A. N. Puri ..	
Dr. C. N. Acharya ..	

2. Physiology—

Dr. B. B. Dikshit ..	*Convener.*
Dr. B. Mukerji ..	*Recorder.*
Mr. Banbihari Chatterji	*Sectional Correspondent.*
Prof. Mahadeva L. Schroff	*Local Sectional Secretary.*
Prof. M. Damodaran ..	*Elected Members.*
Mr. K. Mitra ..	
Prof. W. Burridge ..	*Past Presidents who are Ordinary or Honorary Members.*
Lt.-Col. S. L. Bhatia ..	
Bt.-Col. R. N. Chopra	
Prof. N. M. Basu ..	
Dr. W. R. Aykroyd ..	
Prof. N. M. Basu ..	*Past Recorders who are Ordinary or Honorary Members.*
Dr. S. N. Mathur ..	
Prof. B. Narayana ..	
Dr. B. B. Dikshit ..	

13. Psychology and Educational Science—

Dr. I. Latif	*Convener.*
Dr. Gopeswar Pal ..	*Recorder.*
Mr. M. N. Samanta ..	*Sectional Correspondent.*
Prof. B. L. Atreya ..	*Local Sectional Secretary.*
Dr. B. K. Bagchi ..	*Elected Members.*
Mr. Kali Prasad ..	
Dr. N. N. Sen-Gupta ..	*Past Presidents who are Ordinary or Honorary Members.*
Mr. N. S. N. Sastry ..	
Dr. G. Bose	
Mr. M. N. Banerji ..	
Dr. S. C. Mitra ..	
Mr. J. M. Sen ..	
Mr. K. C. Mukherji ..	
Mr. Haripada Maiti ..	
Dr. D. D. Shendarkar ..	
Mr. N. S. N. Sastry ..	*Past Recorders who are Ordinary or Honorary Members.*
Mr. M. N. Banerji ..	
Mr. D. Ganguly ..	
Dr. D. D. Shendarkar ..	
Dr. I. Latif	

14. Engineering—

Mr. C. C. Inglis ..	*Convener.*
Dr. Anant H. Pandya ..	*Recorder.*
Prof. Surendra Kumar Roy	*Sectional Correspondent.*
Prof. G. C. Mukerjee ..	*Local Sectional Secretary.*
Dr. N. K. Bose ..	*Elected Members.*
Dr. K. C. Chakko ..	

General Arrangements

The Opening Ceremony of the Congress will be held in the Arts College Hall. All Sections will meet in the University Colleges in the following rooms:—

Mathematics and Statistics	Engineering College Room No. 5.
Physics ..	College of Science (Physics Block) Physics new Lecture Theatre (ground floor).
Chemistry ..	Chemistry Lecture Theatre (first floor).
Geology ..	Mining and Metallurgy Dept. (Chemistry Block) Lecture Theatre (ground floor).
Geography and Geodesy	College of Science, Lecture Theatre. Geology Dept. (first floor).
Botany ..	College of Science (Physics Block) Lecture Theatre, Dept. of Botany (first floor).
Zoology ..	College of Science (Physics Block) Lecture Theatre, Zoology Dept.
Entomology ..	Engineering College.
Anthropology ..	Engineering College.
Medical and Veterinary Research ..	College of Science (Chemistry Block) Lecture Theatre (ground floor).
Agriculture ..	Institute of Agricultural Research, Lecture Theatre.
Physiology ..	College of Science (Chemistry Block) Dept. of Mining Matallurgy annexe Lecture Theatre.
Psychology and Educational Science ..	College of Science (Physics Block) Physics Lecture Theatre (ground floor).
Engineering ..	Engineering College Room No. 3.

The Office of the Local Secretaries will be opened in the Sayaji Gaekwad Library.

The Office of the General Secretaries will be opened in the Sayaji Gaekwad Library on the 1st January, 1941.

The Information Bureau is located in the Sayaji Gaekwad Library Central Hall.

The Reception Room is located in the Sayaji Gaekwad Library Central Hall. Stationery and writing materials for the use of the members will be available there. A number of the local daily papers will be provided in this room.

A Post and Telegraph Office will be opened in the Sayaji Gaekwad Library. Members may address their letters c/o Indian Science Congress, Benares Hindu University, Benares. All Com-

munications to the Local Secretaries may also be sent to this address from 31st December, 1940.

• A local branch of the Imperial Bank of India is situated in the Physics block of the University.

A Telephone Connection will be available for the use of the members in the Sayaji Gaekwad Library and Physics Block.

A Restaurant where refreshments will be available, will be opened in the Sayaji Gaekwad Library from 2nd January, 1941.

Details of the *Excursions* will be announced in the revised programme.

An interesting programme of visits to institutions of educational, scientific, technical and industrial interest is being arranged, details of which wll be included in the revised programme.

Badges, a Science Congress Handbook (Benares, 1941) and a *List of Members* with their local addresses, where known, together with *Invitation Cards to social functions,* will be issued to members from the Local secretary's Office from the 1st January, 1941 between 9 A.M. and 4 P.M. Members are requested to produce their membership cards when applying for these.

Opening Proceedings and the General Presidential Address:— The Congress will be opened by His Excellency the Governor of United Provinces of Agra and Oudh in the Arts College Hall at 10 A.M. on Thursday, January 2nd, 1941. The Address of the General President will begin immediately afterwards. Members must be in their seats before 9-30 A.M.

The Evening Popular Lectures will be delivered in the Arts College Hall as followss—

FRIDAY, JANUARY 3RD, 1941, AT 6-30 P.M.

'Some Aspects of the development of India's Mineral Resources,' by Dr. Cyril S. Fox, D.Sc., M.I.Min.E., F.G.S., Director, Geological Survey of India, 27, Chowringhee, Calcutta.

SATURDAY, JANUARY 4TH, 1941, AT 6-30 P.M.

'The Earth as a Giant Magnet, by Prof. K. S. Krishnan, D.Sc., F.N.I., F.R.S., Mahendralal Sircar Professor of Physics, Indian Association for the Cultivation of Science, 210, Bowbazar Street, Calcutta.

MONDAY, JANUARY 6TH, 1941, AT 6-30 P.M.

'The Soil and its Conservation,' by Prof. J. N. Mukherjee, D.Sc., F.C.S., F.R.A.S.B., F.N.I., Ghose Professor of Chemistry, University College of Science and Technology, 92 Upper Circular Road, Calcutta.

TUESDAY, JANUARY 7TH, 1941, AT 6-30 P.M.

'Some new application of Colloidal Chemistry.' by Dr. S. S. Bhatnagar, O.B.E., D.Sc., F.Inst.P., F.I.C., Director, Scientific and Industrial Research, Government Test House, Alipore, Calcutta.

DAILY PROGRAMME
(Provisional)

THURSDAY, JANUARY 2ND, 1941.

10 A.M.	..	H. E. the Governor of United Provinces of Agra & Oudh opens the Indian Science Congress Session.
		General President's Address.
12 NOON	..	Meetings of the Sectional Committees (in the rooms of the respective Sections).
3-30 P.M.	..	Meeting of the Council.
4-30 P.M	..	AT HOME by His Highness Maharajdhiraj Dr. Sir Kameshwar Singh Bahadur, K.C.I.E. of Darbhanga and Pro-Chancellor of the Benares Hindu University.

FRIDAY, JANUARY 3RD, 1941.

9 A.M. to 9-30 A.M.	..	Meetings of the Sectional Committees.
9-30 A.M. to 1 P.M.	..	Meetings of Sections.
9-30 A.M.	..	Presidential Address: Section of Agriculture: 'Plant breeding and Genetical Work in India.'
10-30 A.M.	..	Presidential Address: Section of Mathematics and Statistics: 'Functional Analysis and Methematical Physics.'
11 A.M.	..	Presidential Address: Section of Entomology: 'Some Observations on the Periodicity of Locust Invasions in India.'
12 NOON	..	Presidential Address: Section of Geology: 'Palaeogeographical Revolutions in the Indo-Burmese Region and Neighbouring Lands
10-30 A.M. to 12-30 P.M.		(1) Discussion on 'Drought resistance in plants.' (SECTION OF AGRICULTURE).
		(2) Discussion on 'The psychological factors in adult education.' (SECTION OF PSYCHOLOGY AND EDUCATIONAL SCIENCE).
		(3) Discussion on 'Sugar Technology.' (SECTION OF CHEMISTRY).

10-30 A.M. to 12-30 P.M.	(4) Discussion on 'Corelational analysis of Anthropometric material.' (SECTION OF ANTHROPOLOGY, IN CO-OPERATION WITH THE INDIAN STATISTICAL CONFERENCE).
	(5) Discussion on 'The Curricula for B.Sc. (Hons.) examination in the various Indian universities; their adequacy or otherwise for fitting graduates to undertake research work.' (SECTION OF BOTANY).
	(6) Discussion on 'Physiographic divisions of India.' (SECTION OF GEOGRAPHY AND GEODESY).
1-30 P.M. to 2 P.M. ..	Discussion on 'Detribalization and Acculturation.' (SECTION OF ANTHROPOLOGY).
2-30 P.M. to 4-30 P.M.	Discussion on 'Boundary value problem in differential equations.' (SECTION OF MATHEMATICS AND STATISTICS).
1 P.M. to 4-30 P.M. ..	The various Science and Technological Departments of the Benares Hindu University will be open for visit by the members.
2-30 P.M. ..	Meeting of the Executive Committee.
6-30 P.M. ..	Popular Lecture on 'Some Aspects of the development of India's Mineral Resources,' by Dr. Cyril S. Fox, D.Sc., M.I.Min.E., F.G.S., Director, Geological Survey of India, 27, Chowringhee, Calcutta.
9 P.M. ..	Special Meeting of the General Committee to consider the question of Regrouping of Subjects into Sections.

SATURDAY, JANUARY 4TH, 1941.

9 A.M. to 9-30 A.M. ..	Meetings of the Sectional Committees.
9-30 A.M. to 1 P.M. ..	Meetings of Sections.
9-30 A.M. ..	Presidential Address: Section of Botany: 'The Respiration of Plants in Light.'
10-30 A.M. ..	Presidential Address: Section of Physics: 'The Role of Applied Physics in Industry.'
11-30 A.M. ..	Presidential Address: Section of Physiology: 'Some Observations on Sleep.'

12 NOON ..	Presidential Address: Section of Anthropology: 'Anthropology in the Service of the Individual and the Nation.'
11 A.M. to 12-30 P.M.	(1) Discussion on 'Environment and the distribution of population in India.' (SECTION OF GEOGRAPHY AND GEODESY).
	(2) Discussion on 'The place of Psychology in the field of Medicine.' (SECTIONS OF PSYCHOLOGY AND EDUCATIONAL SCIENCE AND MEDICAL AND VETERINARY RESEARCH).
	(3) Discussion on 'Mathematical Theory of Statistics.' (SECTION OF MATHEMATICS AND STATISTICS, IN CO-OPERATION WITH THE INDIAN STATISTICAL CONFERENCE).
	(4) Discussion on 'Position of systematics in Applied Zoology and Entomology.' (SECTIONS OF ENTOMOLOGY AND ZOOLOGY).
2 P.M. ..	River Trip on the Ganges.
2 P.M. to 3-30 P.M. ..	(1) Discussion on 'Conflict and social behaviour.' (SECTION OF PSYCHOLOGY AND EDUCATIONAL SCIENCE AND ANTHROPOLOGY).
	(2) Discussion on 'Growth studies with special reference to Nutrition and Public Health Surveys.' (SECTION OF MEDICAL AND VATERINARY RESEARCH, IN CO-OPERATION WITH THE INDIAN STATISTICAL CONFERENCE).
	(3) Discussion on 'Standards of Agricultural Productivity.' (SECTION OF GEOGRAPHY AND GEODESY).
2 P.M. to 4-30 P.M. ..	Discussion on 'Theory of Stellar Structure.' (SECTIONS OF PHYSICS AND MATHEMATICS AND STATISTICS).
2-30 P.M. to 3-30 P.M.	Lecture on 'Salt from the East Lake Bitterns Area.' by Dr. H. B. Dunnicliff. (SECTION OF CHEMISTRY).
6-30 P.M. ..	Popular Lecture on 'The Earth as a Giant Magnet,' by Prof. K. S. Krishnan, D.Sc., F.N.I., F.R.S., Mahendralal Sircar Professor of Physics, Indian Association for the Cultivation of Science, 210, Bowbazar Street, Calcutta.

9-15 P.M.	..	Variety Entertainment.

SUNDAY, JANUARY 5TH, 1941.

Whole day Excursion to

(1) Opium Factory, Ghazipur.

(2) Sarnath.

(3) Sugar, Paper and Cement Factories, Dalmianagar, Dehri-on-sone.

MONDAY, JANUARY 6TH, 1941.

9 A.M. to 9-30 A.M.	..	Meetings of the Sectional Committees.
9-30 A.M. to 1 P.M.	..	Meetings of Sections.
9-30 A.M.	..	Presidential Address: Section of Chemistry: 'Physico-chemical Studies of Gels.'
10-30 A.M.	..	Presidential Address: Section of Zoology: 'Some Aspects of Mammalian Placenta.'
11-30 A.M.	..	Presidential Address: Section of Geography and Geodesy: 'Conservation of India's Natural Resources.'
11 A.M. to 12-30 P.M.		(1) Discussion on 'Sulphanilamide group of drugs.' (SECTIONS OF PHYSIOLOGY, CHEMISTRY AND MEDICAL AND VETERINARY RESEARCH).
		(2) Discussion on 'Need for the exploration of wild forms for the improvement of crops.' (SECTIONS OF AGRICULTURE AND BOTANY): President: Rao Bahadur T. S. Venkatraman, C.I.E.
		(3) Discussion on 'Theory of the Structure of Solids.' (SECTIONS OF MATHEMATICS AND STATISTICS AND PHYSICS).
		(4) Discussion on 'Biological Control—Its possibilities and its limitations.' (SECTIONS OF ENTOMOLOGY AND AGRICULTURE).
		(5) Discussion on 'Racial Nomenclature.' (SECTION OF ANTHROPOLOGY).
1-30 P.M.	..	Meeting of the Sub-Committee on 'Science and its Social Relations.'

2 P.M. ..	(1) Discussion on 'Reasons for the lag in India of utilization of medical knowledge by the individual and initial steps towards solving the problem.' (SECTION OF MEDICAL AND VETERINARY RESEARCH AND SUB-COMMITTEE ON 'SCIENCE AND ITS SOCIAL RELATIONS'): President: Dr. B. C. Ray.
	(2) Discussion on 'Simbolism and Rituals.' (SECTIONS OF PSYCHOLOGY AND EDUCATIONAL SCIENCE AND ANTHROPOLOGY).
	(3) Discussion on 'Utilization of India's Mineral Resources.' (SECTIONS OF GEOLOGY AND GEOGRAPHY AND GEODESY).
3-30 P.M. ..	Meeting of the General Committee.
6-30 P.M. ..	Popular Lecture on 'The Soil and its Conservation,' by Prof. J. N. Mukherjee, D.Sc., F.C.S., F.R.A.S.B., F.N.I., Ghose Professor of Chemistry, University College of Science and Technology, 92, Upper Circular Road, Calcutta.
8-15 P.M. ..	Subscription Dinner.

TUESDAY, JANUARY 7TH, 1941.

9 A.M. to 9-30 A.M. ..	Meetings of the Sectional Committees.
9-30 A.M. to 1 P.M. ..	Meetings of Sections.
9-30 A.M. ..	Presidential Address: Section of Medical and Veterinary Research: 'Some Aspects of Public Health in India.'
10-30 A.M. ..	Presidential Address: Section of Engineering: Hydrodynamic Models as an aid to Engineering Skill.'
11-30 A.M. ..	Presidential Address Section of Psychology and Educational Science: 'Psychology and the Future of Mankind.'
10-30 A.M. to 12-30 P.M.	(1) Disucssion on 'Quality in crops.' (SECTIONS OF AGRICULTURE, CHEMISTRY AND MEDICAL AND VETERINARY RESEARCH): President: Dewan Bahadur Sir T. Vijayaraghavacharya, K.B.E.

10-30 A.M. to 12-30 P.M.	(2) Discussion on 'Work of the Botanical Survey of India. What the Botanical Section of the Science Congress could do to advance it.' (SECTION OF BOTANY).
	(3) Discussion on 'Diophantic problem.' (SECTION OF MATHEMATICS AND STATISTICS).
1-30 P.M. ..	Discussion on 'Nitrogen fixation in the soil.' (SECTIONS OF BOTANY, AGRICULTURE AND CHEMISTRY).
3-30 P.M. ..	Meeting of the Executive Committee.
4-30 P.M. ..	AT HOME to Delegates by Rai Govind Chand, M.A., M.L.A.
6-30 P.M. ..	Popular Lecture on 'Some new application of Colloidal Chemistry,' by Dr. S. S. Bhatnagar, O.B.E., D.Sc., F.Inst.P., F.I.C., Director, Scientific and Industrial Research, Government Test House, Alipore, Calcutta.

WEDNESDAY, JANUARY 8TH, 1941.

9 A.M. to 9-30 A.M. ..	Meetings of the Sectional Committees.
9-30 A.M. to 1 P.M. ..	Meetings of Sections.
11 A.M. to 12-30 P.M. ..	(1) Discussion on 'Food planning.' (SECTIONS OF MEDICAL AND VETERINARY RESEARCH, PHYSIOLOGY, AGRICULTURE, GEOLOGY, ENGINEERING AND GEOGRAPHY AND GEODESY).
1-30 P.M. to 3 P.M. ..	Discussion on 'Practical steps towards the improvement of Museums in India.' (SECTIONS OF GEOLOGY, ANTHROPOLOGY AND BOTANY).
2 P.M. ..	Discussion on 'Standard yields of crops.' (SECTION OF AGRICULTURE, IN CO-OPERATION WITH THE INDIAN STATISTICAL CONFERENCE).
3-30 P.M. ..	Photograph of the Reception Committee, the Presidents and Delegates.
4 P.M. ..	Reception Committee AT HOME to Delegates.

Meetings of the Learned Societies

THURSDAY, JANUARY 2ND, 1941.

12 NOON ..	Annual Meeting of the National Institute of Sciences of India.

2 P.M. to 4 P.M. .. H. E. the Governor of United Provinces of Agra & Oudh opens the Indian Statistical Conference.

FRIDAY, JANUARY 3RD, 1941.

8-30 A.M. to 9-30 A.M. Ordinary monthly meeting of the National Academy of Sciences, India.

1-30 P.M. to 2-30 P.M. (1) Annual Meeting of the Society of Biological Chemists, India.
(2) Annual Meeting of the Indian Physical Society.
(3) Annual Meeting of the Indian Psychological Association.
(4) Annual Meeting of the Physiological Society of India.
(5) Annual Meeting of the Entomological Society of India.
(6) Annual Meeting of the Indian Botanical Society.

3 P.M. to 4-30 P.M. .. Annual Meeting of the Benares Mathematical Society. (Tea to members).

3-30 P.M. to 4-30 P.M. Annual General Meeting of the Indian Pharmaceutical Association.

5 P.M. .. Engineering Students' Society presents an address to Sir Ardeshir Dalal.

SATURDAY, JANUARY 4TH, 1941.

3-30 P.M. to 4-30 P.M. (1) Annual Meeting of the Indian Society of Soil Science.
(2) Annual Meeting of the Institute of Chemistry of Great Britain and Ireland (Indian Section).
(3) Symposia by the Indian Pharmaceutical Association.
(4) Symposium on 'Recent work on the base exchange properties of various soils.' (THE INDIAN SOCIETY OF SOIL SCIENCE, IN CO-OPERATION WITH THE SECTION OF AGRICULTURE OF THE INDIAN SCIENCE CONGRESS).

MONDAY, JANUARY 6TH, 1941.

2-30 P.M. .. Annual Meeting of the Indian Chemical Society.

TUESDAY, JANUARY 7TH, 1941.

1-30 P.M. .. Meeting of the Indian Ecological Society.

8 P.M. .. Meeting of the Indian Society of Plant Breeding and Genetics.

SPECIAL PUBLICATIONS

OF THE

Indian Science Congress Association

The Progress of Science in India during the Past Twenty-five Years. Edited by B. Prashad, D.Sc., F.R.S.E., F.R.A.S.B., F.N.I., Director, Zoological Survey of India, Indian Museum, Calcutta .. Rs. 5-0-0 per copy

A review of the researches carried out in India in different scientific subjects during the period 1910 to 1937.

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An exposition of the manifold field problems involved in the study in India of such subjects as Meteorology, Oceanography, Geology, Botany, Zoology, Ethnology, Agriculture, Animal Husbandry and Archaeology.

The publications or information about them are obtainable from the office of the Indian Science Congress Association, 92, Upper Circular Road, Calcutta.

PROCEEDINGS

OF THE

Indian Science Congress

The price list of the Proceedings from the 1st (1914) to the 27th (1940) Session are available on enquiry from the General Secretary of the Indian Science Congress Association, 92, Upper Circular Road, Calcutta.

Commercial Gazette Press—Calcutta

Proceedings of the Twenty-eighth Indian Science Congress.

PART I.

CONTENTS.

PROCEEDINGS OF THE TWENTY-EIGHTH INDIAN SCIENCE CONGRESS.

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1. OFFICERS OF THE TWENTY-EIGHTH CONGRESS.

PATRON:

HIS EXCELLENCY SIR MAURICE GARNIER HALLETT, K.C.S.I., C.I.E., I.C.S., THE GOVERNOR OF THE UNITED PROVINCES OF AGRA AND OUDH.

VICE-PATRONS:

PANDIT MADAN MOHAN MALAVIYA, B.A., LL.B.
SIR SARVAPALLI RADHAKRISHNAN, KT., F.B.A., D.LITT., LL.D.

PRESIDENT:

SIR ARDESHIR DALAL, KT., I.C.S. (RETD.).

PRESIDENTS OF SECTIONS:

Mathematics and Statistics.—Prof. M. R. Siddiqi, Ph.D., F.N.I., Professor of Mathematics, Osmania University College, Hyderabad-Deccan.

Physics.—Prof. P. N. Ghosh, M.A., Ph.D., Sc.D. (Hons.), F.Inst.P. (Lond.), F.N.I., Ghose Professor and Head of the Department of Applied Physics, University College of Science and Technology, 92, Upper Circular Road, Calcutta.

Chemistry.—Prof. Mata Prasad, D.Sc. (Benares), F.I.C., F.N.I., Professor of Inorganic and Physical Chemistry, Royal Institute of Science, Fort, Bombay.

Geology.—Dr. M. R. Sahni, M.A. (Cantab.), Ph.D., D.Sc. (London), D.I.C., F.A.Sc., Geological Survey of India, 27, Chowringhee, Calcutta.

Geography and Geodesy.—Dr. S. M. Tahir Rizvi, B.A. (Hons.) (Lond.), Ph.D. (Lond.), M.A., LL.B., F.R.G.S., F.R.Met.S., Bar.-at-Law, Chairman, Department of Geography, Muslim University, Aligarh.

Botany.—Dr. Shri Ranjan, M.Sc. (Cantab.), Docteur ès Sciences, Reader in Botany, Allahabad University, Allahabad.

Zoology.—Prof. A. Subba Rau, B.A., D.Sc., F.R.M.S., Professor of Zoology, Central College, Bangalore.

Entomology.—Rao Bahadur Y. Ramchandra Rao, M.A., F.R.E.S., Locust Research Entomologist, Imperial Council of Agricultural Research, 6, Lakshmi Building, New Delhi.

Anthropology.—Tarak Chandra Das, Esq., M.A., Lecturer in Anthropology, Calcutta University; 93, Ballygunge Place, Calcutta.

Medical and Veterinary Research.—A. C. Ukil, Esq., M.B. (Cal.), M.S.P.E. (Paris), F.S.M.F.B., F.N.I., Director, Tuberculosis Inquiry, Indian Research Fund Association, All India Institute of Hygiene and Public Health, 110, Chittaranjan Avenue, Calcutta.

Agriculture.—K. Ramiah, Esq., M.B.E., M.Sc., Dip. Agri. (Cantab.), L.Ag., Geneticist and Botanist, Institute of Plant Industry, Indore (Central India).

Physiology.—Dr. B. B. Dikshit, M.B.B.S., M.R.C.P., D.P.H., Ph.D., Officer-in-Charge, Department of Pharmacology, Haffkine Institute, Parel, Bombay.

Psychology and Educational Science.—Dr. I. Latif, M.A., Ph.D., Head of the Department of Psychology and Director, Child and Youth Guidance Clinic, Forman Christian College, Lahore.

Engineering.—C. C. Inglis, Esq., C.I.E., B.A., B.A.I., M.Inst.C.E., M.Am.Soc. of C.E., Director, Central Irrigation and Hydro-dynamic Research, Poona.

RECORDERS OF SECTIONS:

Mathematics and Statistics.—Prof. S. C. Dhar, M.A., D.Sc. (Cal. and Edin.), P.R.S., F.R.S.E., F.N.I., Head of the Department of Mathematics, College of Science, University of Nagpur, Nagpur (C.P.).

Physics.—Prof. R. K. Asundi, B.A. (Hons.), M.Sc. (Bom.), Ph.D. (Lond.), Professor of Physics, Benares Hindu University, Benares.

Chemistry.—Dr. M. Qureshi, M.Sc., Ph.D., F.N.I., Head of the Department of Chemistry, Osmania University College, Hyderabad-Deccan.

Geology.—Dr. A. S. Kalapesi, B.A., B.Sc. (Bom.), Ph.D., D.I.C., F.G.S. (Lond.), St. Xavier's College, Cruickshank Road, Bombay 1.

Geography and Geodesy.—Prof. Maneck B. Pithawalla, D.Sc., B.A., L.C.P., F.G.S. (Lond.), M.R.A.S. (Lond.), M.R.S.T. (Lond.), Professor of Geology, N.E.D. Engineering College, Karachi, (up to Dec., 1940). A. K. Banerjee, Esq., Teachers Training Dept., Calcutta University, Calcutta, (from 1st Jan. to 31st Jan., 1941).

Botany.—Dr. P. Anand, M.Sc. (Hons.), Ph.D. (Lond.), Professor of Biology, S.D. College, Lahore.

Zoology.—J. L. Bhaduri, Esq., M.Sc., Zoological Laboratory, University College of Science and Technology, 35, Ballygunge Circular Road, Calcutta.

Entomology.—Dr. P. Sen, M.Sc., Ph.D., D.I.C., Entomologist, Malaria Research Laboratory, Bengal Public Health Department, 94, Chittaranjan Avenue, Calcutta.

Anthropology.—Dr. A. Aiyappan, M.A., Ph.D. (Lond.), F.R.A.I., Curator, Anthropological Section, Government Museum, Egmore, Madras.

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Prof. N. K. Tiwari.
Mr. S. S. Roy.
Capt. B. Chatterji.
Prof. R. L. Merh.
Dr. R. B. Pande.
Prof. S. C. De.
Mr. Sarju Prasad.
Mr. L. K. Singh.
Mr. N. L. Singh.
Mr. G. P. Srivastava.
Mr. Sankatha Prasad.
Dr. Y. Bharadwaja.
Mr. K. R. Mehta.
Mr. Chandra Bal.
Mr. K. N. Gupta.
Mr. R. C. Saxsena.
Mr. V. L. Powar.
Dr. G. N. Pathak.
Miss K. Vankateswaran.
Mr. J. D. Jaiswal.
Pt. G. S. Mishra.

4. GENERAL.

The Twenty-eighth Meeting of the Indian Science Congress Association was held at Benares from January 2nd to January 8th, 1941.

The inaugural meeting was held on Thursday, January 2nd, 1941, at 10 A.M. in the Sayaji Rao Gaekwad Library Hall, Hindu University, Benares, in the presence of the Patron, His Excellency Sir Maurice Garnier Hallett, K.C.S.I., C.I.E., I.C.S., the Governor of the United Provinces of Agra and Oudh. Professor Sir Sarvapalli Radhakrishnan, Kt., F.B.A., D.Litt., LL.D., Vice-Chancellor, Hindu University, Benares, Chairman of the Reception Committee, welcomed the delegates in a speech and requested His Excellency the Governor of the United Provinces of Agra and Oudh to open the Session of the Congress. His Excellency opened the Congress with a speech and the President of the Congress, Sir Ardeshir Dalal, Kt., I.C.S. (Retd.), delivered his address.

The Sectional Presidential Addresses were delivered as follows:—

Friday, January 3rd : 9-30 A.M., Agriculture; 10-30 A.M., Mathematics and Statistics; 11 A.M., Chemistry *; 12 noon, Geology.

Saturday, January 4th : 9-30 A.M., Botany; 10-30 A.M., Physics; 10-30 A.M., Physiology; 12 noon, Anthropology.

Monday, January 6th : 10 A.M., Entomology †; 10-30 A.M., Zoology; 11-30 A.M., Geography and Geodesy.

Tuesday, January 7th : 9-30 A.M., Medical and Veterinary Research; 10-30 A.M., Engineering; 11-30 A.M., Psychology and Educational Science.

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* The Presidential Address was fixed for delivery on Monday, January 6th, but the date was changed as the President of the Section of Entomology could not be present to deliver his address and the President of the Section of Chemistry agreed to deliver his address on this date.

† As the elected President of the Section was, owing to unavoidable reasons, unable to attend the Session, Mr. D. D. Mukerji, who was chairman of the Meeting read out the Address.

Symposia and Joint Meetings of Sections were held as follows:—

Friday, January 3rd :

10-30 A.M. to 12-30 P.M.

Discussions on	Held in
(1) 'Drought resistance in plants.'	The Section of Agriculture.
(2) 'The Psychological factors in adult education.'	The Section of Psychology.
(3) 'Sugar Technology' ..	The Section of Chemistry.
(4) 'Correlational analysis of Anthropometric material.'	The Section of Anthropology, in co-operation with the Indian Statistical Conference.
(5) 'The Curricula for B.Sc. (Hons.) examination in the various Indian Universities; their adequacy or otherwise for fitting graduates to undertake research work.'	The Section of Botany.
(6) 'Physiographic divisions of India.'	The Section of Geography and Geodesy.

1-30 P.M. to 3 P.M.

(7) 'Detribalization and Acculturation.'	The Section of Anthropology.

2-30 P.M. to 4-30 P.M.

(8) 'Boundary value problem *in differential equations*.'	The Section of Mathematics and Statistics.

Saturday, January 4th :

11 A.M. to 12-30 P.M.

(9) 'Racial Nomenclature' ..	The Section of Anthropology.
(10) 'Environment and the distribution of population in India.'	The Section of Geography and Geodesy.
(11) 'The place of Psychology in the field of Medicine.'	The Joint Meeting of the Sections of Psychology and Educational Science, and Medical and Veterinary Research.

Discussions on	Held in
(12) 'Mathematical Theory of Statistics.'	The Section of Mathematics and Statistics, in co-operation with the Indian Statistical Conference.
(13) 'Position of systematics in Applied Zoology and Entomology.'	The Joint Meeting of the Sections of Entomology and Zoology.

2 P.M. to 3 P.M.

(14) 'Conflict and Social behaviour.'	The Joint Meeting of the Sections of Psychology and Educational Science, and Anthropology.
(15) 'Growth studies with special reference to Nutrition and Public Health Surveys.'	The Section of Medical and Veterinary Research in co-operation with the Indian Statistical Conference.
(16) 'Standards of Agricultural Productivity.'	The Section of Geography and Geodesy.
(17) 'Recent advances in the Chemistry of Coumarins and Chromones.'	The Section of Chemistry.

2 P.M. to 4-30 P.M.

(18) 'Theory of Stellar Structure.'	The Joint Meeting of the Sections of Physics, and Mathematics and Statistics.

Monday, January 6th:

11 A.M. to 12-30 P.M.

(19) 'Sulphanilamide group of drugs.'	The Joint Meeting of the Sections of Physiology, Chemistry and Medical and Veterinary Research.
(20) 'Need for the exploration of wild forms for the improvement of crops.'	The Joint Meeting of the Sections of Agriculture and Botany.
(21) 'Theory of the structure of solids.'	The Joint Meeting of the Sections of Mathematics and Statistics, and Physics.
(22) 'Utilization of India's mineral resources.'	The Joint Meeting of the Sections of Geology, and Geography and Geodesy.

Discussions on	Held in
2 P.M.	
(23) 'Reasons for the lag in India of utilization of medical knowledge by the individual and initial steps towards solving the problem.'	The Joint Meeting of the Section of Medical and Veterinary Research and the Sub-Committee on 'Science and Social Relations'.
(24) 'Symbolism and Rituals'	The Joint Meeting of the Sections of Psychology and Educational Science, and Anthropology.

Tuesday, January 7th :

10-30 A.M. to 12-30 P.M.

(25) 'Quality in crops' ..	The Joint Meeting of the Sections of Agriculture, Chemistry, and Medical and Veterinary Research.
(26) 'Work of the Botanical Survey of India: What the Botanical Section of the Science Congress could do to advance it.'	The Section of Botany.
(27) 'Diophantic problem' ..	The Section of Mathematics and Statistics.
1-30 P.M.	
(28) 'Nitrogen fixation in the soil.'	The Joint Meeting of the Sections of Botany, Agriculture, and Chemistry.

Wednesday, January 8th :

11 A.M. to 12-30 P.M.

(29) 'Food Planning' ..	The Joint Meeting of the Sections of Medical and Veterinary Research, Physiology, Agriculture, Geology, Engineering, and Geography and Geodesy.
1-30 P.M. to 3 P.M.	
(30) 'Practical steps towards the improvement of Museums in India.'	The Joint Meeting of the Sections of Geology, Anthropology, and Botany.

Popular Lectures were delivered as follows:—

Friday, January 3rd, 1941: 6-30 P.M.

'Some new application of Colloidal Chemistry,' by Sir S. S. Bhatnagar, Kt., O.B.E., D.Sc., F.Inst.P., F.I.C., Director, Scientific and Industrial Research, Government Test House, Alipore, Calcutta.

Saturday, January 4th, 1941: 6-30 P.M.

'The Earth as a Giant Magnet,' by Prof. K. S. Krishnan, D.Sc., F.N.I., F.R.S., Mahendralal Sircar Professor of Physics, Indian Association for the Cultivation of Science 210, Bowbazar Street, Calcutta.

Monday, January 6th, 1941: 6-30 P.M.

'The Soil and its Conservation,' by Prof. J. N. Mukherjee, D.Sc., F.C.S., F.R.A.S.B., F.N.I., Ghose Professor of Chemistry, University College of Science and Technology, 92, Upper Circular Road, Calcutta.

Tuesday, January 7th, 1941: 6-30 P.M.

'Some Aspects of the development of India's Mineral Resources,' by Dr. Cyril S. Fox, D.Sc., M.I.Min.E., F.G.S., Director, Geological Survey of India, 27, Chowringhee, Calcutta.

The following Functions and Entertainments were held in honour of the Members of the Indian Science Congress:—

Thursday, January 2nd : 4-30 P.M., At Home by the Hon'ble Maharajadhiraj Dr. Sir Kameshwar Singh Bahadur, K.C.I.E., D.Litt., LL.D., of Darbhanga and Pro-Chancellor of the Hindu University, Benares, at the Sayaji Rao Gaekwad Library lawn.

Friday, January 3rd : 4-15 P.M., 'At Home' by the Engineering Students at the Engineering College.

Saturday, January 4th : 4-30 P.M., Civic Reception and Address to Sir Ardeshir Dalal, President, and Indian Science Congress delegates at the Town Hall; 8-45 P.M., Variety Entertainment at the Congress Pandal.

Sunday, January 5th : 8-45 P.M., Variety Entertainment at the Congress Pandal.

Monday, January 6th : 4-30 P.M., Garden Party by the Gentry of Benares in the Sayaji Rao Gaekwad Library lawn.

Tuesday, January 7th : 4-30 P.M., Garden Party by Rai Govind Chand, M.A., M.L.A., in the Sayaji Rao Gaekwad Library lawn.

The following Visits and Excursions were arranged for Members of the Indian Science Congress Association:—

Friday, January 3rd : 1 P.M. to 4-30 P.M., The various Science and Technological Departments of the Benares Hindu University were open for visit by the members.

Saturday, January 4th : 2 P.M., River Trip on the Ganges; visit to *Kalabhavan, Nagari Pracharini Sabha.*

Sunday, January 5th : Whole day excursions:

To (1) Opium Factory, Ghazipur.
(2) Sarnath.
(3) Sugar, Paper and Cement Factories, Dalmianagar, Dehri-on-Sone.

The following Meetings were held during the Session of the Indian Science Congress:—

THE SECTIONAL COMMITTEES met at (1) 6 P.M. on Thursday, January 2nd; (2) 9 A.M. on Friday, January 3rd; (3) 9 A.M. on Saturday, January 4th; (4) 9 A.M. on Monday, January 6th; (5) 9 A.M. on Tuesday, January 7th; (6) 9 A.M. on Wednesday, January 8th, 1941.

THE COUNCIL met at 3-40 P.M. on Thursday, January 2nd, 1941.

THE EXECUTIVE COMMITTEE met at (1) 2-30 P.M. on Friday, January 3rd; (2) 3-30 P.M. on Tuesday, January 7th, 1941.

THE GENERAL COMMITTEE met at (1) 9 P.M. on Friday, January 3rd; (2) 3-30 P.M. on Monday, January 6th, 1941.

THE SUB-COMMITTEE on 'Science and its Social Relations' met at 1-30 P.M. on Monday, January 6th.

The following Scientific Societies held their Meetings during the Twenty-eighth Session of the Congress:—

1. The Annual Meeting of the National Institute of Sciences of India was held at 12 noon on Thursday, January 2nd, 1941.
2. The Opening Session of the Indian Statistical Conference was held at 2-30 P.M. on Thursday, January 2nd, 1941.
3. The Annual Meeting of the Society of Biological Chemists, India, was held at 1-30 P.M. on Friday, January 3rd, 1941.
4. The Annual Meeting of the Indian Physical Society was held at 1-30 P.M. on Friday, January 3rd, 1941.
5. The Annual Meeting of the Indian Psychological Association was held at 1-30 P.M. on Friday, January 3rd, 1941.

6. The Annual Meeting of the Physiological Society of India was held at 1-30 P.M. on Friday, January 3rd, 1941.

7. The Annual Meeting of the Entomological Society of India was held at 1-30 P.M. on Friday, January 3rd, 1941.

8. The Annual Meeting of the Indian Botanical Society was held at 1-30 P.M. on Friday, January 3rd, 1941.

9. The Annual Meeting of the Benares Mathematical Society was held at 3 P.M. on Friday, January 3rd, 1941.

10. The Annual General Meeting of the Indian Pharmaceutical Association was held at 3-30 P.M. on Friday, January 3rd, 1941.

11. The Annual Meeting of the Indian Society of Soil Science was held at 3-30 P.M. on Saturday, January 4th, 1941.

12. The Annual Meeting of the Institute of Chemistry of Great Britain and Ireland was held at 3-30 P.M. on Saturday, January 4th, 1941.

13. The Annual Meeting of the Indian Chemical Society was held at 2-30 P.M. on Monday, January 6th, 1941

14. A Meeting of the Indian Ecological Society was held at 1-30 P.M. on Tuesday, January 7th, 1941.

15. A Meeting of the Indian Society of Plant Breeding and Genetics was held at 8 P.M. on Tuesday, January 7th, 1941.

16. An Ordinary Monthly Meeting of the National Academy of Sciences, India, was held at 8 A.M. on Friday, January 3rd, 1941.

5. OPENING PROCEEDINGS.

The Twenty-eighth Meeting of the Indian Science Congress was opened on Thursday, January 2nd, 1941, at 10 A.M., by His Excellency Sir Maurice Garnier Hallett, K.C.S.I., C.I.E., I.C.S., Governor of the United Provinces of Agra and Oudh, in the Sayaji Rao Gaekwad Library, Hindu University, Benares, in the presence of Professor Sir Sarvapalli Radhakrishnan, the Vice-Chancellor of the Benares Hindu University and Vice-Patron of the Session of the Congress, and a large gathering of delegates, members and visitors. Seats were specially reserved for the Presidents, Past Presidents, Sectional Presidents, the Local Secretaries, the General Secretaries, the Treasurer, the Chairman of the Local Reception Committee, and special delegates from foreign Scientific Bodies and Universities, Learned Societies, Colleges, States and Government Departments in India. Professor Sir Sarvapalli Radhakrishnan, Vice-Chancellor and Chairman of the Local Reception Committee, announced message of congratulation and good wishes from Pandit Madan Mohan Malaviya, the Vice-Patron of the Session of the Congress, who could not join the function, and welcomed the delegates and visitors in a speech as follows:—

YOUR EXCELLENCY, SIR ARDESHIR DALAL, DELEGATES OF THE SCIENCE CONGRESS, LADIES AND GENTLEMEN,

It is with great pleasure that I welcome you to the University of Benares and request you to accept the cordial good wishes of the members of the University and of the Reception Committee for the success of your meetings in the next few days. We are aware of the many shortcomings in the arrangements and the difficulties to which you are put and I apologize to you in advance and beg you to forgive us.

Benares has been accustomed for centuries to receive pilgrims not only from the different parts of India but from beyond the seas, from Burma and Ceylon, from Tibet and Thailand, from China and Japan. There are few cities in the world which can compete with her for her antiquity or for her hold on the imagination and affections of large numbers of men. When we stand here, we are conscious of a civilization and a culture, a philosophy and a religious life of unbroken continuity for nearly fifty centuries. I welcome you to this ancient city and beg you to have a glimpse of that other life for which she has stood, if you find any interval between your excursions and engagements.

While this University was founded with the object of preserving the traditions of Benares as a centre of religious

culture and learning, its chief architect perceived the great need of correlating the religious traditions of the past with the urgent problems of the present, due to the development of science and criticism. We have departments here for the pursuit of scientific research and its application to agriculture and industry and our scientific technological and engineering departments occupy an important place in our life and organization.

A university, if it is true to its name, should pay equal attention to the different manifestations of the human spirit, literature and philosophy, art and religion as well as science and technology. The purpose of scientific studies is to discover the truth about things and the patient workers in laboratories are as much imaginative creators as poets and philosophers. Those who help us to cut across mountains, to collect waters over thousands of miles to irrigate barren tracts and make them blossom, to subdue the elements of nature to the uses of man are benefactors of the human race. In a country like ours, where there is a vast amount of dirt and disease, poverty and uncleanness, the case for the spread of the scientific spirit and habits cannot be overestimated. The gifts of science help to make life fuller, wider, healthier and richer in comforts and interests and in such happiness as material things can promote.

Unfortunately there has been for some time a suspicion of science. As long ago as 1749 the Academy of Dijon announced a prize for the best discussion of the question : 'Has the progress of science and art contributed to the corruption or to the improvement of morals ?' Rousseau competed for it and gave an answer adverse to science. From what I have said already, it will be evident that we, in this university, do not share his view. We believe in scientific progress and industrial development. We are sorry that our resources, natural and human, are not adequately developed. We deplore the policy of the Government which has not helped the country to build motor engines, ships of all kinds and aircrafts. With proper organization and State support India can become the chief industrial centre of the East and how much we can do in this direction is manifest from the work of the Tatas, and it is most appropriate that we should have as our President in this important session the head of that great industrial enterprise, Sir Ardeshir Dalal. I am sure that this session will be a momentous one under his wise and versatile leadership.

There are, I dare say, many who believe with Rousseau that science has corrupted our morals. A Bishop of England asked us to close down our laboratories for a decade or two. Addressing the Cambridge University Lord Baldwin asked them to produce more poets than scientists. Sir Richard Livingstone, said with irony, 'The Greeks could not broadcast Aeschylean Trilogy but they could write it'. If science is being perverted from its natural purpose, if it is used not for the happiness of mankind

as a whole, but for private profit and public destruction, it is not the fault of science or the scientists. If there is chaos in the economic world, if cows are slaughtered for manure, if wool is used for roadmaking, if coffee is burnt and wheat thrown into the sea, while there are men and women undernourished and badly nourished it is not the fault of science. If the political world is anarchical, if scientific weapons are used for destruction and human slaughter elevated into a cardinal centre, it is not the fault of science. One of the greatest scientists of all ages said: 'The present troubles of the world are due to science having advanced faster than morality; when morality catches up with science these troubles will end' (*Einstein*). Our progress is not integral if moral advance does not accompany scientific achievement. The problem of our age is the reconciliation of science and wisdom in a vital harmony. Where else can it be achieved if not in the great universities?

At any rate in this University, it is our aim to insist on the high mission of science and relate it organically to the central purpose of human life and society, to reconcile religious wisdom with scientific achievement.

In this endeavour there can be no differences of party or creed. The people and the Government have the same objective. It is a pleasure to know that two of the prominent members of your Congress have been honoured by His Majesty's Government. I refer to Sir R. N. Chopra and Sir S. S. Bhatnagar. May I, on behalf of this assembly, offer to them our warmest congratulations.

Once again I welcome you to this University, beg you to accept our hospitality, forgive us our shortcomings and accept our best wishes for your comfortable stay and successful meetings.

It is now my pleasure to request His Excellency, who has heartened us by his presence, to open the Congress.

His Excellency the Governor of the United Provinces of Agra and Oudh then addressed the meeting as follows:—

MR. PRESIDENT, MR. VICE-CHANCELLOR, GENTLEMEN,

It is a pleasure and privilege for me as Governor of the United Provinces to welcome so many distinguished men of learning to this Province. Calcutta, Madras and Lahore have been fortunate in recent years to have been chosen as the site for your annual conference, and now that the turn of the United Provinces has come again, we welcome you cordially and hope that you will enjoy your stay here in this ancient city of Benares. This is not the first time the Congress has met in Benares as it was here in 1925 and has been to Lucknow in 1916 and 1923 and to Allahabad in 1930—so it is no stranger to this Province. Here you who stand for progress and look forward to future development of human knowledge, will find the glories and

traditions of the past. The scientific thinker strives to find new truth, but here for centuries men have sought knowledge, for centuries Benares has been the home of learning. Meeting here in Benares you have yourselves recognized the contributions which ancient India in her ancient language made to scientific studies and I understand that a volume recording the contributions to science by those scholars of old is under compilation which deals with the contributions by scholars of these early academies to mathematics, to astronomy and to chemistry. The Benares Hindu University has set up a school of medicine in accordance with Ayurvedic principles founded on the old Sanskrit treatises and modern application thereof. But with all that it cannot be denied that your choice of Benares as a meeting place does bring before us very vividly two attitudes to life, the attitude of pure contemplation and the attitude of active investigation.

You have been good enough to make me Patron of your Conference and I greatly appreciate the honour which you have bestowed on me. It is an honour which I do not merit, for I never had a scientific education and I am afraid I should understand but little of your deliberations. But that does not mean that I am cynical about the value of scientific research. The search for scientific knowledge is no new thing, but what is comparatively new is the general realization of its value when applied to the ordinary problems which meet us day to day. We see with amazement the products of the inventive genius of this age, motor cars, aeroplanes, the wireless, but until recently we were apt to regard the laboratory or the test-tube as the paraphernalia only of academic investigation. But in the last two decades we have seen how knowledge acquired laboriously in the study of the laboratory can be applied to the everyday problems of life; scientific knowledge and the search for it has been recognized by the ordinary man in the street as playing a part in the development of the State no less vital than the improvement of its communications, the construction of better buildings and the more obvious activities of social improvement. For example, looking through your daily programme, I find that you propose to discuss drought resistance in plants, the psychological factors in education, sugar technology, crop improvement and the control of disease. These are not academic matters. They are matters vitally affecting the villager, upon the solution of which depends in a great measure his happiness and comparative prosperity. If the designation of some of the subjects on the agenda is beyond the comprehension of the layman, he knows that sooner or later this research will lead to practical and obvious results which will benefit humanity.

In a country of the size of India it is always of value for men whose purpose and interests in life are the same to meet. It is the experience of all of us that correspondence is a poor

substitute for the spoken word. But this is doubly true of science. Distances make it difficult for busy men to meet and the value of periodical conferences such as this which enable the expert in his own line to discuss his own ideas and problems with his equals, to pick up the threads upon which others are working, cannot be over-rated. It has been said that the scientist offers new lamps for old, but at a time when the lights have gone out all over Europe such an offer may meet with a negative. The midst of a war like the present where the utilitarian and destructive results of science are so apparent is perhaps not a time to dwell on the beneficent results of the scientists' activities—or so it is sometimes argued. 'Would that swift ships had never been' said the poet and this has been echoed by many an observer of the results of flight which at present is concentrated on the ruthless bombing, the slaughter of women and children or the destruction of the marvels of architecture and treasure houses of the past, when the scientist seems but the agent who puts devilish weapons in the hands of maniacs seeking to destroy civilization. We are faced with the growth of scientific discovery which seems to have outdistanced the wit of man to employ it usefully and beneficently. We grope in the wake of huge forces whose uses we scarcely understand and to control which we are mere fumbling tyros —mere apprentices in a colossal workshop where machines are the masters and we the slaves. It is to find out some path from amidst this jungle of giant growths, conjured up by our half conscious brains that such meetings as this are useful. The scientist stands aghast at his own discoveries, or worse, does not perceive what their real significance is. That the by-products of his experiments may produce destruction on a scale unknown before, is not, he says, his concern—it is a result of the evil spirit inherent in mankind. Why is this evil spirit rampant in the world? Why are the beneficent discoveries of science being prostituted to works of death and destruction? One reason is that we live in a world in which we are at present reaping the harvest of nationalism run wild. The narrow outlook which does not see beyond political boundaries, which is constrained by parochial and immediate self-interest, has brought our civilization to the edge of destruction. But science has always been international, and it is interesting to recall that it was the great German poet Goethe who said that 'science and art belong to the whole world and the barriers of nationality vanish before them'. If the German nation had not become blind to this truth, the world might have been spared the tragedy of the present time. Except when science has been applied to the production of engines of war, the discoveries of men of science to whatever nation they may belong have always been available for the enlightenment of other countries. In the common search for knowledge international meetings of scientists, meetings such

as this is on a smaller scale, have always been conducted on the basis that the search for knowledge is a service of mankind and not the narrow furthering of the interests of any particular race or sect. We cannot but regret that at the present time scientific men throughout the world are devoting themselves to war work, to producing engines of destruction or to devising methods of warding off destruction. We can only hope that many of these discoveries will prove of use when peace is once more restored and that we shall be able to beat our swords into ploughshares and our spears into pruning hooks. We may hope that the war may have at least one good result for this great country, that it will lead to industrial development and the starting of new industries. For that development to be successful, we shall need scientific knowledge and for that reason this Conference is of great importance at the present time.

Here in India as in the world outside we have our differences, and difficulties, racial, religious and ideological, and we are often prone to give them an importance which they do not deserve. But you in your meeting here have no such difficulty. Your particular subjects and individual interests may be diverse, but they are not divergent. Diverseness gives a broad base to the pyramid but the apex of the pyramid to which all your efforts converge is the greater happiness of mankind. We are doing what we can in this Province to develop scientific education. Science has played a leading part in our universities of Allahabad and Lucknow especially where distinguished scientists like Dr. Saha and Dr. Sahni, both Fellows of the Royal Society, have established traditions which will remain. Our Engineering College at Roorkee still in spite of recent difficulties sets the standard for civil engineering and the Institute of Research at Cawnpore known as the Harcourt Butler Institute of Technology has with success attempted to introduce the methods of science into the commercial sphere. The Universities at Benares and Aligarh are both alert and while Benares has developed a school of mechanical and mining engineering and a centre for China technology, Aligarh is starting a department of electrical engineering. At Agra the Agra College is engaged in interesting and valuable botanical work. There are three agricultural colleges in the Province, and the Forest Research Institute at Dehra Dun has developed very greatly the use of forest produce on scientific lines. Finally, there is an active and energetic body in the United Provinces Academy of Science now known as the National Academy of Sciences of India. The need for sound scientific education has been well understood. Dr. Jenkins in the Jubilee meeting of this Congress stressed the need for a good foundation of scientific training to be laid in the schools. In this Province every boy in a secondary school has to take a compulsory course in elementary science which gives a general instruction in those scientific principles of not only chemistry and

physics, but also biology and physiology, which, it has been recognized, should form a part of every system of education. More than this. In our newly introduced system of basic education a compulsory subject is general or everyday science which is taught from the infants class of the vernacular primary school, and is taught through observation and practical work. Basic education aims at inculcating an attitude to life, and the understanding of those basic scientific principles which are part of life cannot be taught too early and they form a system of instruction by which the child learns to observe and deduce for himself—this is the scientific spirit *in petto*. Such being the foundations on which our education rests it is anticipated that in the new world which lies before us when this war is over and victory crowns our efforts, the future rulers and legislators, taxpayers and voters of India will at once be able to appreciate the problems which must face them with a single mind cleared of the lumber of old undigested slogans and superstitions and be prepared to harness science to the chariot of that progress to independence and prosperity which awaits her.

Gentlemen, I welcome you once again to this Province, I wish your Conference every success and I have much pleasure in declaring this Conference open.

At the end of His Excellency the Governor's speech, the President Sir Ardeshir Dalal delivered his Address.*

The official delegates of the following Learned Societies then extended on behalf of the respective society to the Indian Science Congress Association their greetings and best wishes for the success of the Session of the Congress:—

National Academy of Sciences, India.
Pacific Science Association.
American Association for the Advancement of Science.
National Institute of Sciences of India.

The meeting terminated with votes of thanks to His Excellency the Governor of the United Provinces of Agra and Oudh proposed by Prof. B. N. Singh, Local Secretary, and to the Local Reception Committee proposed by Principal P. Parija, I.E.S., M.A., F.N.I., General Secretary.

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* Published in Part II of the Proceedings.

6. OFFICIAL.

A. DELEGATES FROM OUTSIDE INDIA.

American Association for the Advancement of Science.

1. Prof. S. P. Agharkar.
2. Prof. B. N. Singh.

Pacific Science Association.

1. Dr. Paul F. Russell.

B. DELEGATES FROM UNIVERSITIES, LEARNED SOCIETIES, COLLEGES, STATES AND GOVERNMENT DEPARTMENTS IN INDIA.

Agra University.

1. Mr. Eknath Banerji.
2. Mr. D. P. Bhattacharya.
3. Mr. P. T. Chandi.
4. Dr. K. C. Pandya.
5. Dr. Ramamurti.

University of Allahabad.

1. Prof. A. C. Banerji.
2. Dr. D. R. Bhattacharya.
3. Dr. Ram Saran Das.
4. Dr. S. B. Dutt.
5. Mr. A. K. Mittra.
6. Dr. B. N. Prasad.
7. Dr. Shri Ranjan.
8. Dr. B. K. Singh.
9. Dr. B. N. Srivastava.
10. Dr. Murli Dhar Lal Srivastava.
11. Dr. A. N. Tandon.

Aligarh Muslim University.

1. Dr. Kazi Saeeduddin Ahmad.
2. Dr. Mohd. Afzal Hosain Kadri.
3. Mr. S. M. Kerawala.
4. Dr. R. H. Siddiqi.

Andhra University.

1. Prof. S. Bhagavantam.
2. Dr. K. V. Giri.
3. Dr. N. S. Nagendranath.
4. Dr. G. Gopala Rao.
5. Dr. I. Ramakrishna Rao.
6. Dr. K. Rangadhama Rao.
7. Prof. T. R. Seshadri.

Annamalai University.

1. Sri P. Srinivasulu Nayudu.
2. Dr. T. S. Raghavan.
3. Sri R. V. Seshaiya.

University of Bombay.

1. Lt.-Col. S. L. Bhatia.
2. Dr. B. B. Dixit.
3. Dr. G. P. Kane.
4. Mr. N. V. Modak.
5. Principal G. R. Paranjpe.
6. Dr. Mata Prasad.
7. Principal N. M. Shah.
8. Dr. K. Venkataraman.

University of Dacca.

1. Dr. K. Banerjee.
2. Dr. Tarapada Banerjee.
3. Dr. K. P. Basu.
4. Prof. N. M. Basu.
5. Prof. S. N. Bose.
6. Dr. N. K. Chatterjee.
7. Dr. J. K. Chowdhury.
8. Dr. P. Maheshwari.
9. Mr. K. C. Mukherjee.
10. Dr. Madhab Chandra Nath.
11. Dr. A. T. Sen.

University of Delhi.

1. Dr. Ram Behari
2. Dr. D. S. Kothari.
3. Dr. Indra Sen.

University of Lucknow.

1. Dr. K. N. Bahl.
2. Dr. W. Burridge.
3. Mr. Bijan Behari Lal.
4. Dr. S. N. Mathur.
5. Dr. R. D. Misra.
6. Mr. B. B. Mukherjee.
7. Mr. M. Raman Nayar.
8. Dr. Birbal Sahni.
9. Mr. P. D. Shukla.
10. Dr. A. N. Singh.
11. Dr. Syed Husain Zaheer.

University of Madras.

1. Sri R. Gopala Aiyar.
2. Mr. George Kuriyan.
3. Sri N. Sundararama Sastry.

Nagpur University.

1. Dr. S. C. Dhar.
2. Dr. M. A. Moghe.

Osmania University.

1. Dr. B. K. Das.
2. Dr. Brij Mohan Lal.
3. Dr. Haji Ghulam Mohamad.
4. Dr. Muzaffaruddin Qureshi.
5. Dr. M. Raziuddin Siddiqi.

University of the Panjab.

1. Mr. B. M. Anand.
2. Mr. P. L. Anand.
3. Mr. Guran Lal Arora.
4. Dr. H. Chaudhuri.
5. Dr. P. L. Kapur.
6. Mr. Dev Raj Puri.
7. Dr. N. A. Yajnik.
8. Dr. Zia-ud-Din.

Patna University.

1. Dr. Phani Bhusan Ganguly.
2. Mr. Gopal Krishna Ghosh.
3. Rai Sahib J. N. Ghosh.
4. Dr. Basudeo Narayan.
5. Mr. P. Parija.
6. Mr. A. C. Roy.
7. Mr. M. N. Rudra.
8. Mr. Dhirendra Nath Sen.

University of Rangoon.

1. Mr. C. G. Beasley.

Ceylon Geographical Society.

1. Mr. K. Kularatnam.

National Academy of Sciences, India.

1. Prof. A. C. Banerji.
2. Rai Sahib Prof. D. R. Bhattacharya.
3. Prof. H. R. Mehra.
4. Dr. Shri Ranjan.
5. Dr. Erwin Schrodinger.
6. Prof. Bawa Kartar Singh.
7. Rai Sahib Dr. P. L. Srivastava.
8. The Hon'ble Sir Shah Muhammad Sulaiman.

National Institute of Sciences of India.

1. Bt.-Col. Sir R. N. Chopra.
2. Prof. M. N. Saha.

Bihar Government.

1. Mr. K. Mitra.

Government of Bombay.

1. Dr. F. R. Bharucha.

Government of United Provinces of Agra and Oudh.

(*a*) Department of Agriculture.

1. Dr. T. S. Sabnis.

(*b*) Department of Veterinary Investigation.

1. Mr. P. G. Pande.

C. FINANCIAL ARRANGEMENTS FOR THE TWENTY-EIGHTH SESSION.

THE LOCAL RECEPTION COMMITTEE.

The Local Reception Committee made all local arrangements necessary for the transaction of the scientific work of the meeting and all local arrangements regarding social function and accommodation of the members of the Congress and the delegates

Financial arrangements for the Session were made by the Local Committee.

D. MEETINGS OF THE GENERAL COMMITTEE, THE COUNCIL AND THE EXECUTIVE COMMITTEE OF THE INDIAN SCIENCE CONGRESS ASSOCIATION.

1. Special Meeting of the General Committee.

A special meeting of the General Committee of the Indian Science Congress Association was held at 9 P.M. on Friday, January 3rd, 1941, in the Institute of Agricultural Research, Benares, to consider the question of Regrouping of Subjects into Sections.

The President, Sir Ardeshir Dalal, being unable to be present at the meeting, Professor S. P. Agharkar was unanimously elected to the chair.

In compliance with the resolution adopted by the General Committee at their special meeting held on January 3rd, 1940, at Madras the Executive Committee recommended for adoption by the General Committee the following Regrouping of Subjects into Sections:

1. Mathematics and Statistics.
2. Physics.
3. Chemistry.
4. Geology and Geography.
5. Botany.
6. Zoology and Entomology.
7. Anthropology and Archaeology.
8. Medical Sciences.
9. Agricultural Sciences.
10. Psychology and Educational Science.
11. Engineering.

The Chairman, while placing the recommendation of the Executive Committee before the house, pointed out that the decision of the General Committee regarding the regrouping of subjects into Sections would come into effect from the 1943 Session of the Congress.

Professor S. K. Mitra, in placing the recommendations of the Executive Committee before the house, stated that the following modifications were made by the Council at their meeting held on January 2nd, 1941:

'That the Section of Agricultural Sciences be named as Agricultural and Veterinary Sciences.'

The Executive Committee at their meeting held on January 3rd, 1941, accepted these and proposed a further modification:

'That the Section of Engineering be named as Engineering and Metallurgy.'

The following recommendations of the Executive Committee as subsequently modified by the Council and the Executive Committee were then considered by the meeting:

1. Mathematics and Statistics.
2. Physics.
3. Chemistry.
4. Geology and Geography.
5. Botany.
6. Zoology and Entomology.
7. Anthropology and Archaeology.
8. Medical Sciences.
9. Agricultural and Veterinary Sciences.
10. Psychology and Educational Science.
11. Engineering and Metallurgy.

Before permitting discussion on the subject, the Chairman pointed out that as the subject had been before the General Committee for a very long time and also discussed by it, it was not necessary to go into observations of a general nature. He suggested that the recommendations of the Executive Committee be adopted *in toto*. He was, however, prepared to allow specific amendments to the proposals being moved, and voted upon after discussion. The following amendments were then moved:

(i) Professor N. M. Basu proposed that the Section of 'Physiology' be retained as an independent Section instead of being merged in the 'Medical Sciences' Section as proposed.

Professor P. S. Varma seconded the above proposal.

After discussion the proposal was put to the vote and carried by a majority.

(ii) Dr. S. N. Ray proposed that the 'Veterinary Sciences' be retained as a part of the 'Medical Sciences' Section as had so long been the case.

Capt. S. Datta seconded the above proposal.

The proposal was discussed and on being put to the vote was carried by a majority.

(iii) Dr. S. P. Chatterjee proposed that the Section of 'Geography and Geodesy' be retained as a separate Section instead of being made a part of the Section of 'Geology and Geography' as proposed.

Dr. M. R. Sahni seconded the above proposal.

The proposal was discussed and on being put to the vote was lost by a majority.

(iv) Mr. D. Mukerji proposed that the Section of 'Entomology' be retained as a separate Section instead of being made a part of the Section of 'Zoology and Entomology' as proposed.

Mr. J. L. Bhaduri seconded the above proposal.

After discussion the proposal was put to the vote. The result being a tie, the Chairman gave his own vote against the proposal and declared the proposal lost by a majority.

The Chairman then put the proposal of the Executive Committee, as amended by the house, to the vote. On the proposal being adopted unanimously, the Chairman announced that the modifications adopted would come into force from the 1943 Session of the Congress.

1. Mathematics and Statistics.
2. Physics.
3. Chemistry.
4. Geology and Geography.
5. Botany.
6. Zoology and Entomology.
7. Anthropology and Archaeology.
8. Medical and Veterinary Sciences.
9. Agricultural Sciences.
10. Physiology.
11. Psychology and Educational Science.
12. Engineering and Metallurgy.

2. Meeting of the General Committee.

A meeting of the General Committee of the Indian Science Congress Association was held at 3-30 P.M. on Monday, January 6th, 1941, in the Institute of Agricultural Research, Benares, with Sir Ardeshir Dalal, the President, in the chair. The following items of business were transacted:

1. The minutes of the proceedings of the last meeting of (*a*) the General Committee held on January 6th, 1940, in the Medical College, Madras; (*b*) the special meeting of the General Committee held at 3-45 P.M.

on January 3rd, 1940, in the Medical College, Madras, to consider the question of Regrouping of Subjects into Sections; and (*c*) the special meeting of the General Committee held at 9-15 P.M. on January 3rd, 1940, in the Medical College, Madras, to consider the question of Science and its Social Relations, were read and confirmed.

2. The President announced the names of the seven Ordinary Members elected to the Executive Committee under Rule 14, and of the seven Ordinary Members elected to the Council under Rule 18, for the year 1941-42:

Executive Committee.	*Council.*
1. Prof. S. P. Agharkar, Calcutta.	1. Prof. Y. Bharadwaja, Benares.
2. Prof. B. C. Guha, Calcutta.	2. Prof. F. R. Bharucha, Bombay.
3. Prof. P. C. Mitter, Calcutta.	3. Prof. H. K. Mookerjee, Calcutta.
4. Prof. G. R. Paranjpe, Bombay.	4. Prof. B. Narayana, Patna.
5. Dr. J. N. Ray, New Delhi.	5. Prof. B. Sanjiva Rao, Bangalore.
6. Prof. M. R. Siddiqi, Hyderabad.	6. Mr. A. C. Ukil, Calcutta.
7. Rao Bahadur T. S. Venkatraman, Coimbatore.	7. Prof. K. Venkataraman, Bombay.

3. (*a*) The President announced at the meeting that the Executive Committee had nominated Mr. D. N. Wadia, M.A., B.Sc., F.G.S., F.R.G.S., F.R.A.S.B., F.N.I., Mineralogist, Ceylon Government, Colombo, as Congress President for the year 1942 and that the nomination was being placed before the General Committee for confirmation.

(*b*) Professor B. Sahni enquired the reasons for revising the prior decision of the Executive Committee as to the nomination of Pandit Jawaharlal Nehru for the office of the Congress President for the 1942 Session.

(*c*) The President pointed out that the proceedings of the Executive Committee being confidential it would not be desirable to discuss them at a General Meeting. He, however, made it clear to the house that Pandit Jawaharlal Nehru being not available due to reasons known to all, the Executive Committee had to revise their decision in favour of Mr. D. N. Wadia. He informed the house that the Executive Committee had decided to nominate Pandit Nehru for 1943 in case he was then available.

(*d*) Professor B. Sahni still insisted that there should be a discussion on the matter.

(*e*) After some discussion Professor J. N. Mukherjee suggested that it be first decided whether the General Committee considered it desirable to discuss the matter or not.

(*f*) The President then addressed the house and pointed out that before proceeding into the matter it should first be decided whether there should at all be any discussion on the motion before the house.

(*g*) The house agreed to the suggestion to take votes to ascertain first whether it would prefer further discussion or not.

(*h*) Votes were then taken by show of hands and the house by a majority expressed its opinion against any discussion on the motion. Professor Sahni expressed his desire that votes should again be taken by ballot. This was allowed by the President and the house again expressed by a majority its opinion against discussing the matter any further.

(*i*) The nomination of Mr. D. N. Wadia as General President for the year 1942 was then confirmed.

4. (*a*) The President announced that the Twenty-ninth Meeting of the Indian Science Congress would be held at Dacca under the auspices of the Centenary Celebrations of the Old Dacca College.

(*b*) The President announced the names of the Sectional Presidents and Recorders of the Twenty-ninth Meeting as follows:

Section.	*President.*	*Recorder.*
1. *Mathematics and Statistics.*	Prof. P. C. Mahalanobis, Professor of Physics, Presidency College, Calcutta.	Dr. Ram Behari, Reader in Mathematics, Delhi University, Delhi.
2. *Physics* ..	Prof. B. B. Ray, Khaira Professor of Physics, Calcutta University, Calcutta.	Prof. G. R. Paranjpe, Principal, Royal Institute of Science, Bombay.
3. *Chemistry* ..	Dr. M. Qureshi, Head of the Chemistry Department, Osmania University, Hyderabad, Deccan.	Prof. S. S. Joshi, Head of the Chemistry Department, Hindu University, Benares.
4. *Geology* ..	Dr. Raj Nath, Head of the Geology Department, Hindu University, Benares.	Mr. V. P. Sondhi, Geological Survey of India, Calcutta.
5. *Geography and Geodesy.*	Mr. George Kuriyan, Head of the Geography Department, Madras University, Madras.	Prof. Nafis Ahmed, Professor of Geography, Islamia College, Calcutta.
6. *Botany* ..	Dr. N. L. Bor, Forest Botanist, Forest Research Institute, Dehra Dun.	Dr. S. N. Das-Gupta, Reader in Botany, Lucknow University, Lucknow.
7. *Zoology* ..	Dr. H. S. Rao, Assistant Superintendent, Zoological Survey of India, Indian Museum, Calcutta.	Dr. B. R. Seshachar, Assistant Professor of Zoology, Central College, Bangalore.
8. *Entomology*	Mr. D. Mukerji, Zoological Laboratory, Calcutta University, Calcutta.	Dr. K. B. Lal, Entomologist to Government, U.P., Cawnpore.
9. *Anthropology*	Prof. M. H. Krishna, Professor of History and Director of Archaeological Research, Maharajah's College, Mysore.	Mr. J. K. Bose, Department of Anthropology, Calcutta University, Calcutta.
10. *Medical and Veterinary Research.*	Dr. C. G. Pandit, Director, King Institute, Guindy, Madras.	Dr. G. D. Bhalerao, Helminthologist, Imperial Veterinary Research Institute, Mukteswar-Kumaun.
11. *Agriculture* ..	Dr. Nazir Ahmad, Director, Cotton Technological Laboratory, Matunga, Bombay.	Mr. N. L. Dutt, Imperial Sugarcane Station, Lawley Road, Coimbatore.
12. *Physiology*	Prof. B. T. Krishnan, Head of the Physiology Department, Medical College, Madras.	Dr. K. P. Basu, Reader in Biochemistry, University of Dacca, Dacca.
13. *Psychology and Educational Science.*	Dr. G. Pal, Department of Psychology, Calcutta University, Calcutta.	Prof. B. L. Atreya, Professor of Philosophy, Hindu University, Benares.

Section.	President.	Recorder.
14. *Engineering*	*Mr. H. P. Philpot, Principal, Engineering College, Hindu University, Benares.	*Dr. A. H. Pandya, Principal, Bengal Engineering College, Sibpur.

5. The following were elected members of the Sectional Committees for the year 1941-42:

1. *Mathematics and Statistics.*	1.	Dr. B. N. Prasad, Mathematics Department, University of Allahabad, Allahabad.
	2.	Dr. B. R. Seth, Hindu College, Delhi.
2. *Physics* ..	1.	Dr. P. C. Mahanti, Lecturer in Applied Physics, Calcutta University, Calcutta.
	2.	Dr. N. R. Tawde, Lecturer in Physics, Royal Institute of Science, Mayo Road, Bombay.
3. *Chemistry* ..	1.	Dr. A. C. Chatterji, Chemistry Department, The University, Lucknow.
	2.	Prof. D. D. Karve, Professor of Chemistry, Fergusson College, Poona.
4. *Geology..* ..	1.	Dr. G. W. Chiplonkar, Department of Geology, Hindu University, Benares.
	2.	Dr. K. P. Rode, Department of Geology, Hindu University, Benares.
5. *Geography and Geodesy.*	1.	Dr. B. B. Mukherjee, Reader in Economics and Sociology, University of Lucknow, Lucknow.
	2.	Khan Sahibzada Muhammad Yusuf, Lecturer, 'Lalazar', Rampur State, U.P.
6. *Botany* ..	1.	Dr. A. C. Joshi, Department of Botany, Hindu University, Benares.
	2.	Dr. S. M. Sircar, Assistant Lecturer in Botany, Calcutta University, Calcutta.
7. *Zoology* ..	1.	Prof. A. B. Misra, Professor and Head of the Department of Zoology, Hindu University, Benares.
	2.	Dr. D. P. Raichoudhury, University Lecturer in Zoology, Calcutta University, Calcutta.
8. *Entomology* ..	1.	Dr. B. C. Basu, Assistant Entomologist, Imperial Veterinary Research Institute, Mukteswar-Kumaun.
	2.	†Rao Sahib T. V. Ramakrishna Ayyar, Retired Government Entomologist, Madras; 'Hrishikesh', Lawley Road, Coimbatore.
9. *Anthropology* ..	1.	Dr. P. C. Biswas, Department of Anthropology, Calcutta University, Calcutta.

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* Mr. H. P. Philpot being unable to accept the office of the President, Dr. A. H. Pandya has been nominated for the office and Mr. N. V. Modak, B.E., M.I.C.E., M.I.E. (India), M.I.M. & C.Y.E., F.R.San.I., City Engineer, Bombay Municipality, Bombay, has been nominated Recorder of the Section.

† Has declined to accept the membership.

	2.	Dr. (Mrs.) I. Karve, Reader in Sociology, Deccan College, Poona.
10. *Medical and Veterinary Research.*	1.	Mr. M. R. Mahajan, Veterinary Investigation Officer, Hyderabad State, Sitarampet, Hyderabad.
	2.	Dr. B. Mukerji, Pharmacologist, Biochemical Standardization Laboratory, All-India Institute of Hygiene and Public Health, Calcutta.
11. *Agriculture* ..	1.	Dr. B. P. Pal, Imperial Economic Botanist, Imperial Agricultural Research Institute, New Delhi.
	2.	Dr. J. S. Patel, Jute Specialist, Indian Central Jute Committee, P.O. Ramna, Dacca.
12. *Physiology* ..	1.	Mr. S. Banerjee, Department of Applied Chemistry, Calcutta University, Calcutta.
	2.	Dr. S. N. Ray, Imperial Veterinary Research Institute, P.O. Izatnagar, U.P.
13. *Psychology and Educational Science.*	1.	Mr. Kali Prasad, Lecturer in Psychology, Lucknow University, Lucknow.
	2.	Dr. Indra Sen, Hindu College, Delhi.
14. *Engineering* ..	1.	Mr. S. P. Chakravarti, Department of Applied Physics, Calcutta University, Calcutta.
	2.	Rao Saheb N. S. Joshi, Executive Engineer, Village Water Supply Scheme, Maharashtra Zone, Poona City.

6. The audited accounts up to November 30th, 1940, were approved.

7. The Budget Estimates for the year 1st December, 1940, to 30th November, 1941, were accepted.

8. (*a*) Considered the following resolution adopted by the Executive Committee in connection with Reserve Fund of the Association and reported it for information of the General Committee (vide Rule 15):

'Resolved that the following Regulation be incorporated in Regulations under Section "III. Financial":

(4) Amounts received on account of Life Membership subscription shall be credited to the Reserve Fund of the Association.'

Resolved that the Regulations adopted by the Executive Committee be approved.

(*b*) In compliance with a resolution adopted by the Council at their meeting at Madras in regard to the question of completing the delivery of Presidential Addresses in the first three or four days of the Session the Executive Committee adopted the following resolution and reported it for information of the General Committee.

'Resolved that (1) Presidential Addresses should be of [illegible] minutes duration, (2) Presidential Addresses should commence from 9-30 A.M., and (3) there should be no afternoon Presidential Addresses.

Resolved further that in the light of the above resolution necessary changes in the Regulations of the Association be made.'

Resolved that additions to and alterations in the Regulations proposed by the Executive Committee be approved.

(*c*) Considered a letter from Dr. B. N. Prasad suggesting change of dates of the Session from January 2nd—January 8th to December 28th—January 3rd of the following year.

The President while placing the matter before the General Committee for decision invited Dr. Prasad to speak on the subject. Dr. Prasad explained the reasons for which he advocated the change and placed the following resolution before the house for adoption:

'Resolved that it be laid down as a permanent principle of the Association that the Session of the Congress would be held from the 28th December to 3rd January of the following year instead of the present practice of holding the Session from the 2nd to the 8th January, the detailed outline of the programme being decided by the Executive Committee as at present.'

Prof. B. Sahni seconded the above resolution of Dr. Prasad.

The resolution was put to vote and was lost.

9. The following votes of thanks were unanimously adopted:

(*a*) A vote of thanks proposed by the President to H.E. the Governor of United Provinces of Agra and Oudh for consenting to be the Patron of the Association for 1941 and for opening the Benares Session.

(*b*) A vote of thanks proposed by the President to Pandit Madan Mohan Malaviya and Sir Sarvapalli Radhakrishnan for consenting to be the Vice-Patrons of the Association for 1941.

(*c*) A vote of thanks proposed by the President to the Benares Hindu University and its Vice-Chancellor.

(*d*) A vote of thanks proposed by the General Secretary to the Government of United Provinces of Agra and Oudh.

(*e*) A vote of thanks proposed by Principal P. Parija, General Secretary, to the Chairman and Members of the Local Reception Committee.

(*f*) A vote of thanks proposed by Professor J. N. Mukherjee, Treasurer, to the Local Secretaries and the Volunteers.

(*g*) A vote of thanks proposed by Professor P. N. Ghosh to the Royal Asiatic Society of Bengal.

(*h*) A vote of thanks proposed by Professor B. Sahni to the President.

(*i*) A vote of thanks proposed by Mr. D. Mukerji to the General Secretaries.

(*j*) A vote of thanks proposed by Dr. A. N. Singh to the Treasurer.

3. Meeting of the Council.

A meeting of the Council of the Indian Science Congress Association was held at 3-40 P.M. on Thursday, January 2nd, 1941, in the Sayaji Rao Gaekwad Library, Hindu University, Benares, with Sir Ardeshir Dalal, Kt., I.C.S. (Retd.), in the chair. The following items of business were transacted:

(1) The minutes of the proceedings of the meeting of the Council held on January 2nd, 1940, were read and confirmed.

(2) Considered the decision made by the Executive Committee in regard to the question of completion of delivery of the Presidential Addresses in the first three or four days of the Session.

The Executive Committee decided as follows:

'Resolved that (1) Presidential Addresses should be of 45 minutes duration, (2) Presidential Addresses should commence from 9-30 A.M., and (3) there should be no afternoon Presidential Addresses.

Resolved further that in the light of the above resolution necessary changes in the Regulations of the Association be made.'

Resolved that the decision of the Executive Committee be adopted for confirmation by the General Committee.

3. In compliance with the resolution adopted by the General Committee at their Special Meeting held on January 3rd, 1940, at Madras the Executive Committee recommended for adoption by the General Committee the following Regrouping of Subjects into Sections:—

(1) Mathematics and Statistics.
(2) Physics.
(3) Chemistry.
(4) Geology and Geography.
(5) Botany.
(6) Zoology and Entomology.
(7) Anthropology and Archaeology.
(8) Medical Sciences.
(9) Agricultural Sciences.
(10) Psychology and Educational Science.
(11) Engineering.

Resolved that the Regrouping of Subjects into Sections as recommended by the Executive Committee be approved for adoption by the General Committee with the modification that the Section of 'Agricultural Sciences' as recommended by the Executive Committee be named as 'Agricultural and Veterinary Sciences'.

4. Mr. W. D. West drew the attention of the Council to the confusion arising out of the Indian Statistical Institute holding their annual conference at the same time as that of the Indian Science Congress Session.

It was suggested by the Council that the General Secretary might enquire from the Secretary of the Indian Statistical Institute if, in the event of a separate Section of Statistics being formed in the Indian Science Congress, it may not be possible on the part of the Institute to discontinue holding their annual conference at the same time as the Session of the Science Congress.

4. Meetings of the Executive Committee.

Ten meetings of the Executive Committee were held during the year 1940-41. The following were among the important items of business transacted:

1. A resolution was adopted to give action to the clause I(1) that the cost of printing of extra pages over 25 of the Proceedings of the Congress should be requested to be borne by the respective Presidents.

2. In view of the fact that in consequence of the outbreak of war the publication of the Fauna of British India has been stopped it was decided to express opinion regarding the value of this series of publication of British India and to request its continuation.

3. Professor S. P. Agharkar was nominated member of the Finance Committee for the Session ending January 31st, 1941.

4. In compliance with the resolution adopted by the General Committee at their special meeting held on January 3rd, 1940, at Madras regarding Regrouping of Subjects into Sections a Sub-Committee consisting of (1) Professor B. Sahni, (2) Professor S. P. Agharkar (3) Professor P. C. Mitter, (4) Dr. Baini Prashad, (5) Professor S. K. Mitra, and (6) Principal P. Parija was formed to consider the matter in detail.

5. Professor B. N. Singh and Professor P. S. Varma were appointed Local Secretaries for the 28th Session of the Congress held at Benares and were also co-opted as Members of the Executive Committee.

6. It was decided that ordinarily enrolment as members of this Association by the participants of a discussion should be insisted upon; but in case any eminent scientist is specially invited to take part in a discussion this rule may be relaxed.

7. The invitation of the University of Dacca to hold the 1942 Session of the Indian Science Congress at Dacca was accepted and the Universities of Travancore and Bombay were informed that the Executive Committee

would be glad to avail themselves of their invitations to hold meetings under their auspices at a later date.

8. The following resolution adopted by the Section of Mathematics was approved by the Executive Committee and transmitted to the Chairman, Federal Public Service Commission:

'The Section of Mathematics adopted a resolution expressing opinion that under existing Regulations candidates, offering Mathematics in the higher competitive examinations, labour under various handicaps and urged on the Public Service Commission the need for investigating the matter. The directions in which the need for a change appeared most urgent were referred to as follows:

In the I.C.S. Examination—

(1) A more detailed syllabus in Mathematics should be drawn.
(2) A syllabus should be more closely related to those of graduation and post-graduation courses in Mathematics in Indian Universities.
(3) In the matter of marks Mathematics should be placed on par with history and other subjects.

In the Audit and Accounts Service Examination—

Candidates offering Mathematics should not be debarred from offering also the paper in Elementary Mathematics.'

9. The following resolution adopted by the Section of Chemistry at Madras was duly forwarded to the Honorary Secretary of the Board recommended:

'At the recommendation of the Committee, consisting of Dr. S. Krishna, Prof. B. B. Dey, Dr. H. K. Sen and Prof. S. S. Bhatnagar with powers to co-opt, appointed by the Sectional Committee, the Section of Chemistry decided to set up a permanent Advisory Board, composed of experts from the various provinces of India, to help in the development of Chemical Industries in the country. The Board, consisting of the following members, with powers to co-opt when necessary, was appointed for the purpose:

Dr. S. S. Bhatnagar, now Sir, (Calcutta).
Dr. J. L. Sarin (Punjab).
Dr. K. Venkataraman (Bombay).
Dr. K. G. Naik (Baroda).
Dr. R. S. Thakor (Nagpur, C.P.).
Dr. N. N. Godbole (Benares, U.P.).
Dr. Sri Krishna (Dehra Dun, U.P.).
Dr. H. K. Sen (Bihar and Orissa).
Dr. B. C. Guha (Calcutta, Bengal).
Dr. J. K. Chowdhury (Dacca, Bengal).
Dr. B. B. Dey (Madras).
Dr. T. R. Seshadri (Waltair).
Dr. K. L. Moudgill (Travancore).
Dr. J. C. Ghosh (Bangalore).
Dr. B. L. Manjunath (Bangalore).

The duties of the Board which was decided include the following:—

(*a*) The preparation of reports on the availability of the principal raw materials, chemicals and plants, sources of power, cost, etc., for the founding of chemical industries.
(*b*) The suggestions of problems for research with the object of starting definite chemical industries, and the allocation of these problems to the different research institutions in the country.
(*c*) The co-ordination of the results of such researches and the publicity thereof.

(*d*) The supply of reliable technical and other information to private enterprises in the country.

In order that the fullest advantage might be taken of the deliberations of such Board it is recommended that the members should be in constant touch with each other and meet at least once in the year during the Session of the Indian Science Congress, one of the members, preferably Dr. H. K. Sen, acting as the Honorary Secretary of the Board for the present.'

10. In consideration of the following resolution the President of the Section of Geography and Geodesy for the 28th Session was requested to send concrete proposal in this connection in consultation with the Sectional Committee:

'The Geography and Geodesy Section adopted a resolution requesting the Executive Committee of the Indian Science Congress Association to inform the Census Commissioner for India for 1941 and the Census Superintendents of the Provinces and Estates that the Section of Geography and Geodesy of the Indian Science Congress Association is willing to co-operate with the Census Officers in the production of maps, diagrams, etc.'

11. The following resolution adopted by the Section of Zoology at Madras was duly forwarded to the Convener requesting him to consult with the Sectional Committee of Botany also in this connection:

'The Zoology Section adopted the following resolution:

(i) A small Committee should be formed with a view to collect all data, proposals and schemes (including cost) and into the details for supporting an All-India Marine Biological Station in some suitable place in India.

(ii) The Committee may be constituted as follows:

1. Dr. F. H. Gravely (*Convener*).
2. Prof. R. Gopala Aiyar.
3. Prof. K. N. Bahl.
4. Prof. S. G. M. Ramanujam.
5. Prof. George Matthai.
6. Prof. B. K. Das.
7. Dr. J. P. Joshua.
8. Dr. B. Sundara Raj.
9. Prof. C. R. Narayan Rao.
10. Dr. Parthasarathy Aiyangar (Madras)
11. Dr. Raghawan (Annamalai University).

(iii) All proposals, schemes, etc., will be circulated amongst the members of the above-mentioned Committee and a joint memorial will be prepared with the consent of all the members which will be sent to all the Provincial and State Governments, the Central Government and the Universities for grant-in-aid as well as other necessary steps to be taken in this matter.

(iv) The present resources of the Fisheries Department at Krusadai under the Madras Government should be fully utilized and developed.

(v) Due attention should be paid to arrange for a well trained competent staff, laboratory, residence, boarding, etc. The staff should be able to conduct work of a Marine Biological Nature and Marine Biological research and should arrange for a term of teaching work for the various Universities in India, such as refresher's courses and the like.

(vi) With a view to facilitate the drawing up of a memorial, all reports should be placed before the Committee at the next meeting of the Indian Science Congress (the 28th Session to be held at Benares in 1941).

(vii) Two representatives should be co-opted to the Committee, mentioned in (ii) above, from each University, as well as from the Zoological Survey of India.'

12. The following resolutions adopted by the Sections of Entomology and Anthropology were duly forwarded to the University Board:

(*a*) 'The Entomology Section in its joint meeting with the Zoology Section adopted a resolution recommending to the Executive Committee of the Indian Science Congress Association for approaching the Indian Universities for introducing Entomology as a separate subject of study for the M.Sc. Degree Examination and for making adequate provision for the teaching of the subject in the under-graduate courses.'

(*b*) (1) 'The Anthropological Section of the Indian Science Congress is strongly of the opinion that the Anthropological work done at the last Census, both physical and cultural, will lose much of its scientific value if it is not continued during the forthcoming census operations. It is of opinion that the work should be extended as regards scope and geographical areas so as to include castes and tribes not previously studied and should also include a study of blood-groups. It considers it essential that trained workers only should be employed for this work.

(2) The Anthropological Section of the Indian Science Congress Session at Madras reiterates the resolution moved by Prof. Fleure and passed unanimously at the Silver Jubilee Session of the Congres at Calcutta in 1938 "that in view of the urgent necessity of an intensive study of biological traits and social institutions of primitive as well as advanced peoples and cultures in India, it is essential that the Universities and Provincial Administrations should make adequate provisions for the teaching and research in Anthropology".

The Anthropological Section of the Indian Science Congress is also of opinion that in view of the extensive scope for anthropological pre-historic work in South India, the Universities of South India should organize a department of pre-historic and anthropological studies, both cultural and physical, at the earliest possible opportunity. It considers that the institution of a degree course in Archaeology would be the first and most appropriate step towards this end, particularly in the Universities of Madras, Andhra, Annamalai, Mysore, Osmania and Travancore.'

13. The following resolution adopted by the Section of Anthropology at Madras was duly communicated to the Census Department:

'(1) The Anthropological Section of the Indian Science Congress is strongly of the opinion that the Anthropological work done at the last Census, both physical and cultural, will lose much of its scientific value if it is not continued during the forthcoming census operations. It is of opinion that the work should be extended as regards scope and geographical areas so as to include castes and tribes not previously studied and should also include a study of blood-groups. It considers it essential that trained workers only should be employed for this work.'

14. Considering the following resolution adopted by the Section of Agriculture the Executive Committee decided that while agreeing in principle with the resolution adopted by the Section of Agriculture request the Presidents of all the Sections to draw up a list of the topics of discussion for the following year preferably at the first meeting of the Sectional Committee during the Session:

'The Agriculture Section adopted a resolution suggesting that the Sectional Presidents may send round a circular to members of the Sectional Committee in November or early in December each year inviting proposals for topics of discussion for the succeeding year, and such proposals be placed before the Sectional Committee in January for their consideration. It was suggested that this procedure would enable absent members of the Committee to send in their suggestions.'

15. The following deaths of the members of this Association were recorded:

(1) Sir Frederick Hobday, Honorary Member of this Association.
(2) Dr. P. T. Patel, Ordinary Member of this Association.
(3) Mr. Balcrushna Venayek Wassoodew, Ordinary Member of this Association.

16. Invitations were extended to the following Scientific Bodies requesting their representatives at the 28th Session of the Indian Science Congress held at Benares:

(1) British Association for the Advancement of Science, London.
(2) American Association for the Advancement of Science, Washington.
(3) Australian Association for the Advancement of Science, Sydney.
(4) South African Association for the Advancement of Science.
(5) U.S.S.R. Academy of Sciences, Moscow.
(6) Royal Swedish Academy of Sciences, Stockholm.
(7) Imperial Academy of Sciences, Tokyo, Japan.
(8) Pacific Science Congress, California, U.S.A.

17. Messrs. Ray & Ray were appointed auditors for auditing the accounts of the Indian Science Congress Association for the year ending 30th November, 1940.

18. The following Regulation was incorporated in the Regulations under Section III—Financial:

(4) Amounts received on account of Life Membership subscription shall be credited to the Reserve Fund of the Association.

19. It was decided that necessary changes in the Regulation of this Association should be made in compliance with the resolution that (1) Sectional Presidential Addresses should be of 45 minutes duration, (2) Presidential Addresses should commence from 9-30 A.M., and (3) there should be no afternoon Presidential Addresses.

20. A resolution adopted by the Section of Medical and Veterinary Research at Madras suggesting that so long as the present grouping of Medical and Veterinary Sciences in one Section continues it would be desirable to have the President and Recorder selected so that both branches of this Section are represented each year was accepted.

21. It was decided to stop the printing of separates of Abstracts of Papers (Part III).

22. In consideration of the recommendation of the Sub-Committee (appointed by the Executive Committee at their meeting dated 1-1 [illegible]) in the matter of Regrouping of Subjects into Sections of the Congress, the following Sections were recommended for consideration by the General Committee:

(1) Mathematics and Statistics.
(2) Physics.
(3) Chemistry.
(4) Geology and Geography.
(5) Botany.
(6) Zoology and Entomology.
(7) Anthropology and Archaeology.
(8) Medical Sciences.

(9) Agricultural and Veterinary Sciences.
(10) Psychology and Educational Science.
(11) Engineering and Metallurgy.

23. A Sub-Committee consisting of Professor J. N. Mukherjee, Professor S. P. Agharkar and Dr. Baini Prashad was appointed to take steps to recover the publications of the Association lying in the premises of the Royal Asiatic Society of Bengal, Calcutta.

24. Mr. D. N. Wadia was appointed President for the 1942 Session.

5. SUB-COMMITTEE ON 'SCIENCE AND SOCIAL RELATIONS'.

A meeting of the Sub-Committee on Science and Social Relations of the Indian Science Congress Association was held, during the Congress Session held at Benares, on January 6th, 1941, at 1-30 P.M. at the College of Science Building at the Benares Hindu University, when the following business was transacted, with Dr. John B. Grant, Director, All-India Institute of Hygiene and Public Health, Calcutta, in the Chair:

1. Prof. D. D. Kanga proposed and Mr. Boshi Sen seconded the resolution that the annual report, submitted by the Honorary Secretary, be adopted, and the resolution was unanimously carried. It was also resolved that the Committee's thanks be conveyed to the retiring Secretary for his services during the year.

2. In view of the retiring Secretary's remarks with regard to making a provision for stationery, secretarial work, etc., Dr. Grant proposed and Professor Kanga seconded the resolution that each member of the Committee be invited to contribute Rs.10 per year, and the resolution was carried unanimously. Dr. Grant, Professor Kanga, Mr. Boshi Sen, Mr. A. C. Ukil and Dr. Kewal Motwani paid their annual contributions on the spot.

3. Since Dr. C. N. Acharya, the Honorary Secretary of the C.S.S.R., had requested to be relieved of his duties, Dr. Grant proposed and Mr. Boshi Sen seconded the resolution that Dr. Kewal Motwani be elected Honorary Secretary of the Committee, and the resolution was unanimously carried.

4. Dr. Grant proposed and Dr. Motwani seconded the resolution that Mr. A. C. Ukil of the All-India Institute of Hygiene and Public Health be co-opted as a member of the C.S.S.R. The resolution was unanimously carried and Mr. Ukil was invited to join the proceedings of the Committee.

It was further resolved that 'Educational Planning in India' be taken up for discussion at the next annual meeting of the C.S.S.R.

Dr. Grant also suggested that the members of the Committee make use of the magazine 'Science and Culture', edited by Dr. M. N. Saha and others, published in Calcutta.

5. Professor Kanga proposed and Dr. Motwani seconded the resolution that the Committee draft a resolution outlining its scope and activities and that Dr. Grant be authorized to draft the resolution. The resolution was carried.

(A joint discussion was held on 'Reasons for the lag in India of utilization of medical knowledge by the individual and initial steps towards solving the problem' under the auspices of the Sub-Committee on 'Science and Social Relations': see page 20.)

E. RESOLUTIONS ADOPTED BY SECTIONS.

Section of Geography and Geodesy.

Resolved that the Executive Committee of the Indian Science Congress Association should find out from the Census Commissioners for India and the Census Superintendents of the Provinces and the States for the year 1941 whether they need the co-operation of the Section of the Geography and Geodesy in the preparation of maps and diagrams or in any other way in which they think that the services of this section could be of any use of them.

Section of Botany.

Resolved that a Committee consisting of Prof. S. P. Agharkar, Prof. B. Sahni and Prof. P. Parija with Prof. Agharkar as Convener be appointed to represent to the Government of India the necessity of the creation of an Advisory Board including representatives of the Botanical Survey of India, the Indian Universities, the Indian Science Congress and the Indian Botanical Society in connection with the Botanical Survey of India.

The functions of this Board should include determination of the general policy of the Botanical Survey and the allocation of funds for exploration purposes.

Section of Zoology.

Resolved that the Committee formed last year at the Zoology Section of the Indian Science Congress be empowered to send copies of the resolutions and decisions arrived at their meetings at Madras to each one of the members of the Botany and the Zoology Sections and through the General Secretary arrange for a joint meeting of the two Sections at the next year's Science Congress, bringing up its definite proposals and to be included in the agenda.

Resolved further that Dr. B. K. Das be the Convener.

Section of Entomology.

In view of the rapid growth of Entomology and increasing appreciation of its economical importance, this meeting requests the authorities of the Zoological Survey of India and the Imperial Agricultural Research Institute to increase their efforts for the survey of insect fauna of India and to have more sub-sections of Entomology in their museums with the taxonomic experts of respective groups for the identification of insects.

This meeting records its appreciation of the value of the Fauna of British India to economic and academic Zoology and Entomology and views with apprehension the possibility of this series being interrupted or discontinued indefinitely.

Section of Anthropology.

The Anthropological Section of the Indian Science Congress reiterates the resolution passed at the suggestion of Prof. H. J. Fleure at the Jubilee Session of the Indian Science Congress in 1938, and urges on such Indian Universities as have not yet considered the resolution to do so at an early date.

Prof. Fleure's resolution ran thus—'This Conference is of opinion that in view of the urgent necessity of intensive study of biological traits and social institutions of primitive as well as advanced peoples and cultures in India, it is essential that the Universities and Provincial administrations should make adequate provisions for the teaching of Anthropology.'

Section of Agriculture.

Resolved (1) that early and efficient steps be taken through the Imperial Council of Agricultural Research and similar bodies as well as through our Universities to collect together and describe in all aspects the wild species of plants related to the main agricultural crops of the country, and (2) that a committee consisting of Mr. K. Ramiah, Indore, Rao Bahadur T. S. Venkatraman, Coimbatore, Dr. B. P. Pal, New Delhi, and two members selected by the Indian Botanical Society be authorized to work out details in this connection and give effect to the first resolution.

F. RULES AND REGULATIONS, INDIAN SCIENCE CONGRESS ASSOCIATION.

RULES.

1. The name of the Association shall be the Indian Science Congress Association, and its object shall be the advancement of Science in India by the annual holding of a Congress and the doing of all such things as are incidental or conducive to the above object, including—

(a) the holding and management of funds and property;
(b) the acquisition of rights and privileges necessary or convenient for the object of the Association;
(c) the management, development, improvement, disposal, and sale of all and any parts of the property of the Association.

2. The Association shall consist of Ordinary Members, Honorary Members and Session Members.

3. Ordinary Members of the Association shall have the right to contribute papers for reading at the Session of the Congress, to receive free of charge all publications issued by the Association, and to fill any office in the Association on being duly elected thereto.

4. The annual subscription of Ordinary Members shall be Rs.10. The subscription shall become due on the 1st February of each year and shall only be effective as a payment for Ordinary membership subscription if received before the 15th July of the year.

5. Any Ordinary Member may compound for the payment of all future annual subscriptions by the payment in a single sum of Rs.150.

6. Honorary Members shall have all the rights and privileges of Ordinary Members.

Honorary Members, the number of whom shall be limited to fifteen at any one time, shall be persons eminent for their contributions to Science or persons who have rendered conspicuous services to the cause of Science in India.

Honorary Members shall be unanimously nominated by the Executive Committee subject to confirmation by the Council and the General Committee at its annual meeting. Not more than one Honorary Member shall be elected in any year.

7. There shall be three classes of Session Members:—

(a) Full Session Members—subscription Rs.10 per Session.
(b) Associate Session Members—subscription Rs.5 per Session.
(c) Student Session Members—subscription Rs.2 per Session.

8. Full Session Members shall have the right to contribute papers for reading at the Session of the Congress, and to receive free of charge all publications issued by the Association relating to the Session of the Congress of which they are Members.

Associate and Student Session Members shall have the right to submit papers for reading at the Session of the Congress of which they are Members provided such papers be communicated through an Ordinary or an Honorary Member of the Association.

A Student Member shall before admission be duly certified by the head of his Institution to be a *bona fide* student.

Associate and Student Session Members shall receive free of cost the Abstracts of Papers contributed for the Session of which they are members.

9. The official year of the Association shall commence from the 1st of February.

10. There shall be Officers of the Association consisting of the Members of the Executive Committee and Presidents and Recorders of Sections.

11. Only Ordinary and Honorary Members shall hold office in the Association.

12. The term of office of all Officers of the Association except the President shall commence from the beginning of the official year and shall extend until the assumption of office by their successors appointed in accordance with the provisions of these Rules. The President shall assume office on the opening day of the Annual Congress following the one at which he is appointed, and shall continue to hold office until the assumption of office by his successor.

13. There shall be an Executive Committee which shall carry on the administrative work of the Association and submit such questions as it thinks desirable to a General Committee at its Annual Meeting during the Session of the Congress or at a Special Meeting of which due notice shall have been given.

14. The Executive Committee shall consist of the President, the President-elect for the following year, the two General Secretaries, the Treasurer and seven Members, Ordinary or Honorary, elected by the General Committee. For the purpose of this election any Ordinary or Honorary Member may propose the name of an Ordinary or an Honorary Member for election to the Executive Committee. Such proposal must be seconded by another Ordinary or Honorary Member and must reach the General Secretary before the 15th September. The Executive Committee shall circulate these names, together with such other names, not exceeding three, as it may suggest, to all Ordinary and Honorary Members for election by ballot. The ballot papers will be scrutinized by the President and the General Secretaries, and the result of the ballot will be announced at the meeting of the General Committee.

The Executive Committee shall co-opt as Members at least one and not more than two Local Secretaries for the ensuing Session of the Congress.

15. The Executive Committee shall have full power to transact all business in cases of emergency, notwithstanding any limitations hereinafter laid down, and to deal with all matters not otherwise provided for in these Rules, including the making of such Regulations as may appear conducive to the good administration of the Association and the attainment of its object; provided always that such Regulations be not inconsistent with anything contained in these Rules, that they be reported for the information of the next meeting of the General Committee, and that they be subject to rescission or alteration by the Executive Committee or by any meeting of the General Committee.

16. There shall be a General Committee which shall consist of all Ordinary and Honorary Members of the Association.

17. The General Committee shall meet at least once during each Session of the Congress preferably in the middle of the Session.

18. There shall be a Council which shall consist of all Members of the Executive Committee, and all such Ordinary and Honorary Members of the Association as have held office as President, General Secretary, Treasurer, or Managing Secretary of the Association, the Sectional Presidents for the ensuing Session, and in addition seven Members of the Association, Ordinary or Honorary, elected by the General Committee. For the purpose of this election any Ordinary or Honorary Member may propose the name of an Ordinary or an Honorary Member for election to the Council. Such proposal must be seconded by another Ordinary or Honorary Member and must reach the General Secretary before the 15th September. The Executive Committee shall circulate these names, together with such other names, not exceeding three, as it may suggest, to all Ordinary and Honorary Members for election by ballot. The ballot papers will be scrutinized by the President and the General Secretaries, and the results of the ballot will be announced at the meeting of the General Committee.

19. The function of the Council shall be to act as a body of advisers to be consulted by the Executive Committee on important questions of policy or scientific import.

20. There shall be a President who shall be nominated by the Executive Committee and whose nomination shall be submitted to the General Committee at its Annual Meeting during the Session of the Congress for confirmation.

21. There shall be two General Secretaries (one of whom shall be resident in Calcutta) who shall be nominated by the Executive Committee and whose nomination shall be submitted to the General Committee at its Annual Meeting during the Session of the Congress for confirmation.

22. There shall be a Treasurer who shall be nominated by the Executive Committee and whose nomination shall be submitted for confirmation to the General Committee at its Annual Meeting during the Session of the Congress.

23. The term of office of each General Secretary and of the Treasurer shall be for a period of five years following the confirmation of the appointment of any one of them, and each of them shall be eligible for re-appointment.

24. In the event of a vacancy amongst the General Secretaries and the Treasurer occurring between two Sessions of the Congress the Executive Committee shall have power to appoint a General Secretary or the Treasurer for the period up to the termination of the next Session of the Congress.

25. There shall be a Local Secretary or Local Secretaries for each Session of the Congress who shall be appointed by the Executive Committee.

26. There shall be a Local Committee for each Session of the Congress which shall be appointed by the Executive Committee.

27. The Local Secretary, or Secretaries, and the Local Committee shall jointly, on behalf of and in consultation with the Executive Committee, make all necessary arrangements for the holding of the Session of the Congress.

28. For the purpose of scientific deliberation during the Session of the Congress there shall be such Sections corresponding to different branches of science as may from time to time be constituted by the General Committee on the recommendation of the Executive Committee. It shall be competent for any Section after the first day's meeting to hold its scientific meetings in sub-sections for the purpose of dealing separately with different groups of papers submitted to that Section. A separate chairman may be appointed by the Sectional President in consultation with the Sectional Committee to preside over each sub-section.

29. There shall be in each Section a President and a Recorder who shall be appointed by the Executive Committee. In addition there shall be a Sectional Correspondent and a Local Sectional Secretary who shall be appointed by the Executive Committee.

30. In each Section there shall be Sectional Officers, namely, a President, a Recorder, a Sectional Correspondent, and a Local Sectional Secretary. The President and the Recorder shall be the chief executive officers of the Section. They shall have power to act on behalf of the Sectional Committee in any matter of urgency which cannot be brought before the Sectional Committee for consideration, and they shall report such action to the Sectional Committee at its next meeting.

The work of each Section shall be conducted by a Sectional Committee which shall be constituted as follows:—

(a) Sectional Officers.
(b) All Ordinary and Honorary Members of the Association who have been Presidents or Recorders of the Section.
(c) Two Members of the Association, Ordinary or Honorary, elected by the General Committee at its Annual Meeting during the Session of the Congress.

The Sectional President shall preside over all meetings of the Section and of the Sectional Committee. He shall be the convener of the meetings of the Sectional Committee. His ruling shall be final on all points of order that may arise.

The Sectional Recorder shall act as the Secretary of the Sectional Committee, and shall maintain a proper record of the proceedings of the Sectional Committee and of the Section in a book provided for the purpose. He shall be responsible for the punctual transmission to the General Secretary of the recommendations adopted by the Sectional Committee, and of resolutions adopted by the Section.

The Sectional Correspondent shall be resident at the headquarters of the Association, and shall be responsible for preparing for the press the material relating to his Section, according to the instruction of the Sectional President.

The Local Sectional Secretary shall be resident in the locality where the Annual Session is held, and shall be responsible for all local arrangements for the work of his Section, and for arranging the Sectional excursions in consultation with the Local Secretaries.

31. The Sectional Committee shall meet on the opening day of each Session of the Congress, and daily thereafter during the Session before the meeting of the Section unless otherwise determined at a meeting of the Sectional Committee.

In the absence of the Sectional President from any of its meetings the most senior member of the Sectional Committee present shall take the chair.

In their meeting on the opening day they shall

(*a*) nominate a Sectional President and a Sectional Recorder for the ensuing year for the consideration of the Executive Committee;

(*b*) determine the detailed arrangements for the Sectional meetings;

(*c*) select the papers to be read and discussed;

and in their meeting during the Session they shall also

(*d*) nominate a Sectional Correspondent and a Local Sectional Secretary for the ensuing year for the consideration of the Executive Committee;

(*e*) determine the contents of the Sectional records in the Proceedings in accordance with Rule 32 (*e*);

(*f*) consider means of improving the scientific work of the Section, and make suggestions to the Executive Committee whenever considered necessary;

(*g*) select topics for discussions at the next Session of the Congress and make necessary arrangements (i) through the President of the Section concerned for discussions within a Section, and (ii) through the Sectional President who has initiated the proposal for a discussion in which more than one Section will participate.

32. (*a*) All papers submitted for reading at the next Session of the Congress shall be forwarded to the General Secretary so as to reach him not later than September 15th of the calendar year preceding the Session of the Congress at which the papers are intended to be read, provided that this date may be changed by the Executive Committee for special reasons.

(*b*) Any paper submitted for reading at the Session of the Congress shall be accompanied by an abstract in triplicate.

(*c*) All papers submitted for reading at a Session of the Congress shall be checked by the Sectional Correspondent concerned or by such person or persons appointed by the General Secretary. The papers together with a copy each of the abstracts shall then be sent to the Sectional President concerned for refereeing and acceptance. Decisions with regard to acceptance or rejection of any paper shall be final and all reports confidential.

(*d*) No paper published elsewhere shall be accepted.

(*e*) Only abstracts of the paper received by the General Secretary before September 15th in accordance with Rule 32 (*a*), (*b*) and (*c*) shall be printed in Part III of the Proceedings. In exceptional circumstances abstracts of papers received after that date and read before the Section if specially recommended by the Sectional Committee, may be printed in Part IV.

33. The Proceedings of the Indian Science Congress Association shall be published in one volume in four separate parts, as follows:—

I. To contain the list of officers, the proceedings of the opening meeting (except the General Presidential Address) and all official matters.

II. To contain the Presidential Addresses. To be distributed to those present at the meeting after the addresses have been delivered, and to absent Ordinary, Honorary and Full Session Members by post after the meeting.

III. To contain the abstracts of papers to be read before the Sections which are received before September 15th in accordance with Rule 32 (*a*). No abstracts shall be included in this volume from authors who have not already enrolled themselves as Members of the Association. To be distributed in advance of the Meeting to all Members of the Association.

IV. To contain the discussions, late abstracts accepted in accordance with Rule 32 (*e*), the list of members and the index.

34. The following procedure shall be observed for the making of any addition to or alteration in the Rules of the Association:—

(i) Proposals for additions to and alterations in the existing Rules may be placed at any time before the General Committee by the Executive Committee.

(ii) (*a*) Proposals for additions to and alterations in the existing Rules by any Ordinary or Honorary Member of the Association shall be sent to one of the General Secretaries so as to reach him two full months before the meeting of the General Committee in which they are to be moved.

(*b*) One of the General Secretaries shall circulate such proposals to all Ordinary and Honorary Members of the Association at least one full month before the meeting of the General Committee.

(*c*) Any amendments to the proposals shall be sent by any Ordinary or Honorary Member of the Association to one of the General Secretaries so as to reach him at least a fortnight before the meeting of the General Committee.

(*d*) The proposals together with any amendments shall be brought up before the meeting of the General Committee at its Annual Meeting during the Session of the Congress together with any remarks of the Executive Committee and declared carried if accepted by a two thirds majority of the constituent Members present and voting at the meeting.

(Adopted the 5th January 1931. Revised the 5th January, 1935, the 6th January, 1936, the 5th January, 1937, the 8th January, 1939 and the 6th January, 1940.)

REGULATIONS.

1. Sectional Officers.

(1) The President delivers a Presidential Address of which ordinarily the cost of printing 25 pages of the Proceedings in its usual form shall be borne by the Indian Science Congress Association. The time available for delivery of the Presidential Address shall usually not exceed 45 minutes. The manuscript of the address, ready for the press, should be received by the General Secretary before October 15th of the calendar year preceding the Session of the Congress at which the address will be delivered, provided that this date may be changed by the Executive Committee for special reasons. It should be accompanied by 12 copies of a short popular summary (about 500 words) for issue to the lay press. The time and date of the delivery of the President's address will be communicated before the meeting of the Congress. No two Presidential addresses will be delivered at the same time.

(2) The President shall be entitled to receive 30 copies of his address without charge, and additional copies at the cost of reproduction.

(3) Railway fares, postage, clerical or other expenses incurred by the Sectional Presidents, will not be paid by the Association.

(4) The following procedure is adopted for the collection of papers for the Sections:—

About the middle of April a number of copies of a printed circular will be forwarded to the President of each Section who may arrange to send these to workers in that branch of science with which his Section is concerned, requesting them to contribute papers for reading before the next meeting of the Congress.

The circular will contain a clause inviting such workers as are not yet Ordinary Members of the Association to join as such. Particular note should be taken of the fact that no new Ordinary Members are enrolled after the 15th July of the year.

In the case of joint papers, each author must be a Member of some category.

(5) The President referees, either in person or by proxy, the papers received for reading before his Section in accordance with Rule 32.

Abstracts should be limited, except in very special cases, to about 200 words. Long abstracts should be reduced by the President. References to literature in abstracts should be avoided as far as possible and when given should conform to the system of abbreviations used by the Association.

The contents of all abstracts should be carefully checked by the Sectional Correspondent concerned or by such person or persons appointed by the General Secretary, and the abstracts shall then be sent to the Sectional President for his final scrutiny and approval.

Joint discussions on related paper may be held. Authors of papers should be informed of the time allotted by the President to the reading of their papers. An author contributing more than one paper should be asked to specify which of them he would prefer to read at the meeting.

(6) The President, in consultation with the Local Sectional Secretary, shall make arrangements for such local Sectional excursions as seem desirable. Due notice shall be given to the General Secretaries of all such arrangements.

(7) The President and Recorder should, in consultation with other members of the Sectional Committee, make proposals to the General Secretary regarding the programme of the Section. Such proposals should reach the General Secretary not later than the 1st November, so as to enable the necessary details to be entered in the programme. General discussions on questions of importance, held either by a single Section or jointly by two or more Sections, should be encouraged.

The Sectional Presidents concerned shall communicate to the General Secretary before the end of July the titles of such discussions, the names of the speakers and such further information as may be considered necessary.

The Papers, together with three copies of abstracts, to be read by the contributions at a discussion shall be sent to the General Secretary on or before the 15th September of the preceding calendar year by the Sectional President concerned.

The materials relating to a discussion, in a form ready for the press, shall be communicated to the General Secretary within a month from the date on which the discussion takes place; the material not received by the General Secretary within this period shall not be published.

The President and the Recorder of the Section arranging a discussion shall carry out the necessary correspondence throughout the year during which they hold office.

(8) Early in November copies of a printed form will be issued to Presidents of Sections for circulation to members of the Sectional Committees requesting them to nominate a President and a Recorder for the ensuing meeting for consideration by the Sectional Committee. Such proposals shall be accompanied by a statement of qualifications of the nominees for the office and their willingness to accept the same if elected thereto.

During the first week of December, the President of each Section shall circulate all such proposals received by him, together with the statements of qualifications, to the members of the Sectional Committee and request them to nominate by ballot one member for each office from among the list circulated, the ballot papers being received by him up to the 20th December.

At the first meeting of the Sectional Committee held on the Opening Day, the ballot papers shall be opened and scrutinized as the Chairman shall direct and the result communicated to the Executive Committee of consideration, together with a complete record of the Proceedings in this connection.

(9) The duties of the Sectional Correspondent and of the Local Sectional Secretary are given in Rules 30 and 32 (c).

(10) All persons entitled to be members of the Sectional Committee should enrol themselves without delay as Ordinary Members if not already so enrolled and should inform the General Secretary of the payment of their subscription when accepting the appointment.

(11) The General Secretary should be consulted whenever any question arises not dealt with in these regulations.

II. Local Arrangements.

In accordance with the Rules of the Association, the Local Secretaries and the Local Committee shall jointly, on behalf of and in consultation with the Executive Committee, make all necessary arrangements for the holding of the Session of the Congress.

The following arrangements have to be made.

A. *Accommodation for the Scientific Meetings.*

(1) A large hall should be available for (*a*) the President's address on the opening day, and (*b*) for the evening lectures. Both (*a*) and (*b*) are open to the public free of charge. A projection lantern with an operator should be available in this room, and it is a great advantage if loud speakers can be installed.

(2) Rooms for the meetings of the different Sections of the Congress should be provided and suitably furnished. An epidiascope with an operator should be provided in each sectional room. All the rooms

should as far as possible be in close proximity. The following are the sections of the Congress:—

Mathematics and Statistics, Physics, Chemistry, Geology, Geography and Geodesy, Botany, Zoology, Entomology, Anthropology, Agriculture, Medical and Veterinary Research, Physiology, Psychology and Educational Science, and Engineering.

(3) A Reception room should be provided in which Members can get information, write letters, etc. The Local Secretaries' Office should be as near as possible to this room. An arrangement should be made with the Postmaster-General to have a temporary Post Office in this room and for all letters addressed to members c/o The Indian Science Congress to be delivered here. The Indian Science Congress Post Office should be situated as near as possible to the Reception room.

(4) A room near the Reception room should be set apart for the General Secretaries' Office, which will be opened therein from the 31st December.

(5) Provision should be made for lunch in European and Indian styles at moderate charges near the Reception room.

B. *Accommodation for Visiting Members.*

The Local Secretaries should send out, not later than the end of November, a printed circular to all Members enrolled, asking them if they desire that accommodation should be arranged for them. It is desirable, as far as possible, to provide private hospitality for the President, Sectional Presidents, and Officers of the Congress. In this circular information should be given regarding the types of accommodation available, with the charges, and the nature of the climate during the Session. The Local Secretaries will receive periodically from the General Secretary list of Members enrolled at headquarters.

C. *Programme of the Meeting.*

(1) (*a*) The Sections of the Congress meet daily in the morning generally from 9-30 A.M.

(*b*) Presidential Addresses of the Sections shall commence from 9-30 A.M.

(*c*) There should be no afternoon Presidential Addresses of the Sections.

(*d*) Symposia or joint discussions will be held either in the morning, or from 2 P.M.

(2) Public lectures are arranged by the Executive committee, and are given at 6 P.M. or 6-30 P.M.

(3) A printed guide with a map of the locality in which the Congress is held should be prepared for distribution to Members on the opening day. Only Ordinary, Honorary and Full Session Members are entitled to the Guide Book free of cost. A small charge not exceeding Re.1 (to be fixed by the Local Committee) may be made to other Members desiring to have a copy. The Guide Book should contain a summary of information concerning the scientific and educational activities and a short history of the locality, in addition to general information likely to be of use to visitors.

(4) Arrangements should be made for giving due publicity to the activities of the Congress, both before and during the meeting.

(5) A list of Members with their local addresses where known should be printed and distributed on the opening day. A supplementary list should be typed and posted in the Reception room and maintained up-to-date. The Local Secretaries shall arrange for this.

(6) A provisional programme of social engagements should be drawn up by the Local Secretaries and sent to the General Secretary by the

25th November. It is essential that this be sent in time, as it has to be printed and distributed with the abstracts by the first week in December.

The General Secretary will make arrangements for printing the programme drafted as above and distributing these to Members enrolled at the time of the distribution of the abstracts.

The final programme shall be printed locally by the Local Committee in time for the opening of the Session.

D. *General.*

(1) Numbered badges for Members of the Congress will be sent by the General Secretary to the Local Secretaries for distribution on the opening day of the meeting. The badges should bear numbers corresponding to the enrolment numbers. There should be additional badges for Officers.

(2) Members of the Local Reception Committee who have made substantial contributions to the funds of the Local Committee may be given complimentary tickets to attend the meetings.

(3) An audited copy of the accounts of the Local Committee should be sent to the General Secretary not later than the 30th April, following the Session, for inclusion in the Proceedings of the Session. It is desirable that the Local Committee should contribute any surplus to the reserve fund of the Association.

(4) Twelve copies each of all local publications connected with the Congress (guide book, final programme, notices, cards, etc.) should be sent to the office of the Association for record at the conclusion of the meeting.

(5) Applications for membership will ordinarily be dealt with by the General Secretary at the office of the Association up to the 15th December. After that date applications for membership will be forwarded to the Local Secretaries, who will open a separate account for the sale of membership tickets. The amount thus realized, together with unsold tickets, should be forwarded to the General Secretary immediately after the close of the Congress.

III. FINANCIAL.

(1) The accounts of the Association shall be audited once a year and the books closed on the 30th November each year for this purpose.

(2) The audited accounts shall be placed before the General Committee at the Annual Meeting with the observations, if any, of the Executive Committee.

(3) Sanction for all payments for amounts exceeding Rs.100 shall be obtained from the Finance Committee which shall consist of the General Secretaries, the Treasurer, and one Ordinary or Honorary Member resident in Calcutta who shall be nominated by the Executive Committee.

(4) Amounts received on account of Life Membership Subscription shall be credited to the Reserve Fund of the Association.

IV. EXECUTIVE COMMITTEE—ELECTION.

(1) A letter shall be issued asking for nominations giving a last date therefor.

(2) The proposer should ascertain whether the person he proposes is desirous of serving in that particular capacity.

(3) After the nominations have been received the names should be circulated in a ballot paper and the date for return should be fixed two weeks after the ballot paper is sent out.

(Adopted the 5th January, 1937. Revised the 8th January, 1939, the 6th January, 1940 and 6th January, 1941.)

G. STATEMENT OF ACCOUNTS.

I

The Indian Science Congress Association.

Receipts and Payments Account for the year ended 30th November, 1940.

Receipts.

	Rs.	A.	P.	Rs.	A.	P.
To Balance as on 1st December, 1939:						
Imprest Cash	115	0	0			
,, Cash with Imperial Bank of India, Current A/c ..	5,714	11	11			
,, Investments—4% Loan 1960/70 for Rs.10,000 at cost ..	11,416	10	0			
				17,246	5	11
,, Subscriptions:						
Life Members	300	0	0			
Ordinary and Sessional Members	11,543	0	0			
In Advance	10	0	0			
				11,853	0	0
,, Unspent Balance from the Reception Committee, Madras ..	....			437	10	9
,, Annual Contribution received from Bombay University ..	....			500	0	0
,, Sale of Publications ..	....			326	11	6
,, Miscellaneous Receipts ..	....			374	4	6
,, Interest on Investment ..	....			399	0	0
Total ..				31,137	0	8

Payments.

	Rs.	A.	P.	Rs.	A.	P.
By Printing	....			11,485	5	6
,, Postage and Telegrams ..	....			1,539	2	9
,, Salaries	....			2,008	0	0
,, Tour Expenses	....			268	10	0
,, Bank Charges	....			71	6	0
,, Allowances	....			100	0	0
,, Refund of Subscriptions ..	....			27	0	0
,, Contingency:						
Stationery	191	4	3			
Local Conveyance ..	52	7	3			
Badges	92	2	0			
Freight Charges	146	5	9			
Miscellaneous	65	6	0			
				547	9	3
,, Audit Fees	....			50	0	0
,, Balance:						
Reserve Fund Investment:						
4% Loan 1960/70 for Rs.5,000 at cost	5,708	5	0			
With Imperial Bank of India	837	6	9			
	6,545	11	9			
General Investment:						
4% Loan 1960/70 for Rs.5,000 at cost	5,708	5	0			
With Imperial Bank of India, Current A/c	2,670	14	5			
Imprest Cash (as certified) ..	115	0	0			
				15,039	15	2
Total ..				31,137	0	8

Examined with the Books and Vouchers and found in accordance therewith.

Ray & Ray,
Auditors,
Chartered Accountants,
Registered Accountants.

6, Church Lane,
Calcutta, the 13th December, 1940.

J. N. Mukherjee,
Honorary Treasurer.

Proceedings of the Twenty-eighth Indian Science Congress

PART II—PRESIDENTIAL ADDRESSES

CONTENTS

Presidential Address

(*Delivered on Jan. 2, 1941*)

Congress President :—SIR ARDESHIR DALAL, KT., I.C.S. (Retd.).

SCIENCE AND INDUSTRY.

I feel that the authorities of the Indian Science Congress Association have made a very bold departure in electing a layman to the honour of the Presidentship for the year and, deeply conscious as I am of the honour, I confess to a feeling of diffidence in occupying a post which has been adorned by so many distinguished scientists before me. If my address falls short of the standard set by my predecessors, the responsibility of it should in part be borne by those who have elected me. The only reason for their choice, as far as I can see, lies in the fact that I may lay some claims to be an industrialist. So close and intimate is the relationship between science and industry and so strongly is that fact being brought home to us in these days that the Association felt perhaps that they would like to have the views of an industrialist on the relationship of science to industry with particular reference to the practical problems which have arisen in India since the beginning of the war. A substantial part of the export trade of India has been lost since the war. Science can help in the utilization within the country itself of some of the raw materials which used to be exported. Researches are being conducted for instance on the use in India for lubrication purposes of some of the oil seeds of which the export has dwindled down and the surplus of which is likely to create serious economic trouble for the cultivator. Even a more acute problem is the stoppage of the import of many commodities essential for the economic life of the country, such as machinery, chemicals, etc. It is imperative that India should make herself self-sufficient with regard to such materials as are vital to the maintenance of her economic and industrial life so that the situation which had arisen during the last war and which has arisen once again may never recur. It is here that science can be of the greatest assistance to industry. Research has been described as the mother of industry and while some of the older and more traditional industries may have originated without the aid of science, it

Value of Research in Industry.

cannot be denied that all industries to-day depend upon science and research not only for their progress and improvement but also for their survival. Sad experience has proved to us beyond all doubt that, under modern conditions, no nation, however peacefully inclined, can expect even to live an independent existence unless it is highly industrialized. It is the industrial potential that is convertible into the war potential and the country that has the highest industrial potential and is prepared to convert it in the shortest time into war potential that stands the best chance in modern warfare. As we have seen, it is not man power that counts in the highly mechanized warfare of the present day, but planes, tanks, guns, ships and the factories, plants and workshops behind them. The lesson for India is plain and she can only neglect it at her peril. It is no longer the question of a balanced economy or of mere material progress. It is necessary for India's very existence that she should be highly industrialized.

This lesson was first taught during the last world war. Owing to its superior scientific organization and equipment Germany was able to withstand the Allies much longer than she could otherwise have done. At the beginning of that war, England found that she was deficient in many forms of optical glasses, dyestuffs, chemicals and other necessities for the conduct of modern warfare. She set herself to remedy these drawbacks. A very important dye industry was created and the whole of the scientific and research talent of the country was organized by the creation of the Department of Scientific and Industrial Research. It is not necessary for me to enter into the details of the organization and working of the D.S.I.R. with which many of you must be familiar. An interesting feature of the organization, however, to which the attention of the authorities in India needs to be drawn is that the administrative organization of the D.S.I.R. is entirely composed of technical men, while the Advisory Council, which guides and controls its activities, is mainly composed of distinguished scientists with the addition of two or three well-known industrialists and business men. The words of Lord Rutherford to the Twenty-fifth Indian Science Congress, though frequently quoted since then, will bear repetition as they have an important bearing on the policy of the Government of India towards the recently created Board of Scientific and Industrial Research. He said:

'In Great Britain, the responsibility for planning the programmes of research, even when the cost is borne directly by the Government, rests with research councils or committees who are not themselves State servants but distinguished representatives of pure science and industry. It is to be hoped that if any comparable organization is developed in India, there will be a proper representation of scientific men from the universities and corresponding institutions and also of the industries directly concerned. It is of the highest importance that the detailed planning

of research should be left entirely in the hands of those who have the requisite specialized knowledge of the problems which require attack. In the British organizations there is no political atmosphere, but of course the responsibility for allocating the necessary funds ultimately rests with the Government.'

There has been a tendency in the past in India for scientific and research work to be monopolized by Government Departments and although valuable results have been obtained, e.g., by the Survey of India, the Geological Survey, the Botanical Survey and in the investigation of tropical diseases, it is very necessary that organized industrial research should as far as possible be left to scientists and industrialists although of course Government has to see that the grants it makes are properly utilized.

Board of Scientific and Industrial Research.

Industrial research was organized on a country-wide basis in America as well as in several countries of the British Empire following the lessons of the last war. In India also the war revealed the helplessness of the country. The transport service was disorganized owing to lack of railway material; supplies of dyes, important chemicals and many important medicines were almost completely stopped and prices of textiles shot up so high as to be beyond the means of poor people. In 1915 the Government of India addressed the Secretary of State as follows:—

'After the war India will consider herself entitled to demand the utmost help which the Government can afford to enable her to take a place, so far as circumstances permit, as a manufacturing country.'

This policy was accepted by the Secretary of State and the Indian Industrial Commission, under the Chairmanship of Sir Thomas Holland, was set up as a result. Unfortunately, however, the impetus to industrialization provided by the war died down after a few years and many of the industries which were started during the war languished and died. The gathering storm clouds of a new world war drew the attention of Indian scientists to the unorganized state of scientific and industrial research in India and repeated appeals were made for the constitution of a body on the model of the D.S.I.R. The urgent need for the appointment of such a body was voiced by Professor J. C. Ghosh in his presidential address to the Association at Lahore in 1939 and was reiterated in a resolution of this body last year at Madras. The same point was made by Colonel Chopra in his presidential address to the National Institute of Sciences in Madras last year and by Sir M. Visvesvaraya in an address to the Indian Institute of Science, Bangalore. We, therefore, cordially welcome the recent appointment of the Board of Scientific and Industrial Research by the Government of India in response to the demand of scientists throughout the country. Our thanks are due to the present Commerce Member,

Sir Ramaswami Mudaliar, who lost very little time in appreciating the urgency of the constitution of such a body under the conditions created by the war.

I am a member of the Board and keenly interested in its success. Any observations which I may make upon it are made in a purely constructive spirit with the object of enhancing its utility to the country. In the first place then, I may be permitted to say that although the beginning of the Board, like most beginnings, may be small, its conception must be large and liberal. It must not, in its composition or working, bear the appearance of a mere ad hoc body created to meet the immediate exigencies of the war. The demands of the war are no doubt urgent and must have priority over other demands, but the Board should function as a body charged with the organization and promotion of industrial research throughout the country, and co-ordinate the immediate needs of the war with the long range policy of the industrial development of the country as a whole. While concentrating on what is immediately required to meet war needs, it must also be in a position to survey the long term industrial requirements of the country and to plan a programme of research to meet them. Perhaps after the urgent demands of the war are over, its composition can be enlarged and made more representative of the Universities, Government scientific services, the non-official scientific bodies and the industrialists of India so as to enable it to pursue its ultimate plan and policy.

No institution, however well conceived and designed, can flourish except in suitable political atmosphere and conditions. It was the unfortunate experience of the last war that industries created under the stress of the war languished and died in the post-war period for want of encouragement and protection from Government. The activities of the Board will not lead to the creation of new industries unless industrialists are assured of reasonable protection from Government in the post-war period, when foreign competition will be keen.

I have already quoted the words of Lord Rutherford as a warning against excessive Government control. The progress hitherto made by the Board is not as rapid as we would have wished in war time. This is partly due to the constitution of the Board under which executive authority is concentrated in a central department of Government and partly to the inadequate staff provided for the very urgent and important work that has to be done. There is one other aspect on which I desire to touch and that is the financial. Even for a beginning, a grant of Rupees five lakhs is inadequate and shows to my mind an inadequate conception of the magnitude of the tasks involved. Associated with the Department of Scientific and Industrial Research in Great Britain are the great National Physical Laboratory at Teddington and important Boards, such as the

Fuel Research Board, the Food Investigation Board, the Forest Products and Building Research Institutes and a number of similar bodies as well as Research Associations. While we must necessarily make a very modest beginning, the development of the Alipore Test House into a National Physical and Chemical Laboratory seems to be obviously and urgently required. In a subsequent part of this address I shall dwell upon the necessities of a Fuel Research Board to investigate the very pressing problems of fuel and power, upon which the whole industrial structure of the country has to be based. All this work will require large funds but I have not the slighest doubt that the money so spent will be repaid manifold. It has been estimated that the annual expenditure on research in Great Britain in normal times before the war was roughly six million pounds, of which one-half was spent on research directed to industrial needs, including the money spent by Government, University Departments and private firms. The figure for the U.S.A. is estimated to be 300 million dollars, while the corresponding figure of the U.S.S.R. is reported to be of the nature of 120 billion roubles. With the exception of the U.S.A. and the U.S.S.R., there is no country in the world with natural resources so vast and varied as India. With the expenditure of even a fraction of the amount spent by the countries just mentioned on industrial research, these resources can be investigated and developed so as to place India in the front rank of the industrial countries of the world.

The Steel Industry in India.

I propose now in the second part of my address to speak to you on some developments in the steel industry in India during the last ten years; but before doing so I should like to make a few remarks on the raw materials which are commonly used in the manufacture of iron, namely, iron ore, coal and limestone, and particularly coal, which is the most important of our raw materials and of the most general interest.

So far as iron ore is concerned, India is one of the richest countries in the world, being endowed by nature with very extensive deposits of very rich ore. The Singhbhum-Orissa field is the most extensive in India. The tonnage of this field has been estimated by Mr. H. C. Jones of the Geological Survey, at 3,000 millions, and, if anything, it is probably an underestimate. Practically the whole of this ore is hematite, with an iron content of sixty to sixty-nine per cent.

Iron ore.

While the position regarding iron ore is highly satisfactory, that regarding coal, particularly the coal required for the smelting of the iron ore, is far from satisfactory. Dr. Fox has estimated the resources of Indian coal over four feet in thickness up to 2,000 feet in depth and twenty per cent in ash at 24,000 million tons, of which coal of good quality up to

Coal.

18% ash is 6,000 million tons, while coking coal suitable for metallurgical purposes is only 1,400 million tons. Coking coal in India is confined to the Gondwana coal beds of the Damodar Basin. On the existing methods of working coal the total life of the coking coals of India is estimated at about fifty years. This is a position which neither the Government nor those interested in the metallurgical industry can view with equanimity. The most recent Committee appointed by the Government of India to investigate the position and suggest remedies was the Burrows Committee of 1937. The terms of reference to that Committee were unfortunately not comprehensive enough and the legislative measures taken by Government as a result of the recommendations of the Committee are mainly confined to the ensuring of safety in Mines. The problem of Indian coking coals is, however, one of conservation as well as of safety and if proper attention is paid to conservation, the problem of safety will more or less automatically be solved. Legislation in the interest of safety which places additional burdens on the industry without assisting it to dispose of its production in a more scientific manner, is likely to worsen the situation by hastening the uneconomic exploitation of the good coals by the smaller colliery owners. What is required is the rationalization of production as well as of consumption. In order to achieve the rationalization of consumption, a thorough chemical and physical survey of the coalfields beginning with the Jheria coalfield, in conjunction with a scheme of coal utilization research is absolutely necessary. For that purpose it is necessary to create a Fuel Research Board as a branch of the Board of Scientific and Industrial Research with a proper personnel, adequate staff and funds.

Fuel Research Board.

Power is a *sine qua non* of the development of all industries and the proper conservation and utilization of the coal resources of the country is the first question that requires to be tackled in any consideration of the power resources of the country. The geological survey of the various coalfields has been excellently and exhaustively carried out at great expense to Government and it is high time that a scientific, chemical and physical survey were also carried out. Such a survey has been instituted in Great Britain and has resulted in a mass of most valuable information regarding British coals which has in many instances completely altered the attitude of the industry to many varieties of coal and enabled a more efficient use to be made of them.

On the production side the most important problem is that of the co-ordinated sequence of working the coal seams. Perhaps the worst feature of the working of Indian collieries is the exploitation of the richer coal from the lower seams for immediate profit and the neglect of the upper seams resulting in subsidences, fires and destruction of valuable coals. The co-ordinated

sequence of working will prevent this destruction of top seams and will eliminate to a large extent the necessity of stowing altogether. No. 16 seam in the Jheria coalfield is a case in point. This coal has good coking properties but because of its high ash content and doubtful swelling tendencies it has been comparatively unexploited, either as a steam or coking coal.

The washing of coals is another question affecting production. In many cases the ash in the Jheria coals is inherent or when present in a free condition is of about the same specific gravity as the coal itself, thus making the separation impossible or difficult, but it has been proved that in certain of our high ash seams the ash content can be reduced by liquid flotation. 11 and 16 seams Jheria come into this category and further research is necessary to determine whether it is economically feasible to wash these coals with a view to reduce their ash content.

On the consumption side, the chemical and physical survey into our coal seams in conjunction with coal utilization research will in the first place enable us to determine the range and variety of coals suitable for coking as well as boiler purposes. Research is necessary in order to ascertain whether with proper blending and mixing the demands of the metallurgical industry need be confined to the very limited Jheria field. Several experiments have been carried out in the past, but further systematic research by the Board suggested above into blending with high ash coking coals, with swelling coking coals and with non-coking coals may result in the conservation of good coals and an extension of the range of coals available for metallurgical purposes.

Similar research is also required in the case of power coals. A certain amount of information is already available but is mainly confined to the mixing of the high volatile coal in the Raneegunge field with the low volatile coal in the Jheria field for the export market and bunkering only. These low volatile coals from the Jheria are good metallurgical coals and research will doubtless produce suitable blends for export and power requirements without encroachment on these valuable low volatile coking coals.

The utilization of high ash coals for electrical generation at the sources of production and the distribution of the energy thus supplied over large areas is another problem of the first magnitude. The erection of a large power station on the coalfields for the distribution of cheap power to surrounding areas has already been advocated from many sources and has engaged the attention of the Government of Bihar. Further investigation of the suitability of the coal for such a purpose will help greatly towards the fulfilment of this very desirable project and should form one of the first objects of enquiry by the proposed Board.

Low temperature carbonization tests with various classes of coal, particularly of high ash, which are unsuitable for metallurgical purposes and also unsuitable on account of high ash content for transport to distant areas for power purposes, should provide another field for the activities of the Board. A number of scientists from the platform of this Congress as well as outside have advocated the cheap production of domestic coke on a mass scale and the utilization of the resultant tar for industrial purposes. The present very small production of soft coke is capable of very great extension if a market can be found for the coke as well as the resultant tar, even if the gases are ignored for the present. The economic difficulties in the way of such a proposal need not be minimized but practical experiments have already been carried out at Patna under the auspices of the Bihar Government and these would seem to indicate that further research may prove successful. Should this prove to be the case, there would be an adequate supply of raw material for the foundation of hydrogenation plants. This may be regarded as a distant aim as such plants have not proved too successful in other countries, but with the cheap Indian coals and the large quantities of tars which would be available from their low temperature carbonization success may be easier of attainment in India than in other countries.

The Board should also investigate the question of the scientific preparation of coal for the market and buying and selling on specification. This would mean the complete abandonment of the existing unscientific system of grading. The seams which were originally graded, have become exhausted or are nearing exhaustion or have deteriorated to such an extent that the classification is in many cases no longer applicable. The disposal of the metalliferous production of the country has long been established on the international basis of scientific specification and it would be equitable to both buyer and seller alike to establish the buying and selling of coal and coke on a similar basis.

If my proposal for the establishment of a Fuel Research Board is approved, I would suggest that as the Jheria coalfield is practically the sole source of our coking coals and is also the centre of the Indian School of Mines, the headquarters of the Board should be situated at Dhanbad and the School of Mines and its laboratories which should be adequately equipped for the purpose, should be utilized for the investigations of the Board.

THE TATA IRON AND STEEL COMPANY: PROGRESS IN THE LAST DECADE.

The last decade has seen a great expansion of the Steel Industry in India, accompanied by improvement in the various

processes and the application of scientific methods of control. You will forgive me if I confine my remarks to the works of the Tata Iron and Steel Company alone, as the steel-making plant at Bhadravati in the Mysore State was put up in 1936 and has an annual capacity of about 20 000 tons only, while the plant of the Steel Corporation of Bengal with an estimated capacity of two hundred to two hundred and fifty thousand tons of finished steel, has begun operation very recently. In terms of tonnage, the progress can be measured by the fact that while the Tata Iron and Steel Company produced 422,000 tons of finished steel in 1929-30, the corresponding production in 1939-40 was 777,000 tons. Ten years ago only thirty per cent of the demand of the country for steel was met by the indigenous industry, whereas in 1939-40 about eighty-four per cent of the demand was so met and the day is not distant when India will be able to supply not only the whole demand of the country except in a few very specialized directions but also to spare some steel for export.

Following the sequence of the manufacturing processes of steel, I begin with the coke ovens, where the coal is converted into coke. Ten years ago we had three batteries of Wilputte Coke Ovens and two batteries of the still older Koppers Coke Ovens which together produced 720,000 tons of coke, 22,300 tons of tar and 6,600 tons of ammonium sulphate. By 1940 all except one of the Wilputte batteries were replaced by three modern batteries of Simon-Carves Coke Ovens containing 54 to 55 ovens in each battery at a cost of Rupees one crore and sixty-five lakhs. These batteries are of the twinflue 'Underjet' type capable of carbonizing 1,300 to 1,500 tons of coal each per working day. Arrangements have been provided for firing the ovens with coke oven gas or with the cheaper blast furnace cleaned gas. Firing the coke ovens with blast furnace gas releases the more valuable coke oven gas for use in steel making furnaces in other parts of the plant. The twinflue construction assures a more uniform heating throughout the length and height of the oven with a resulting uniformity of the coke produced. As stated in the preceding part of the address, all coals do not give good coke and careful investigations have to be carried out in the blending and mixing of different varieties of coal To this end three large slot bunkers of the capacity of 2,000 tons each have been installed. Coal wagons, as they arrive from the collieries, are taken over to the selected bunkers and unloaded. The coal is then mixed mechanically in the required proportions from the three bunkers and suitable mixed coal is conveyed by mechanical conveyors to the ovens into which it is charged.

Coke ovens.

The three principal by-products of the coke ovens are coke oven gas, ammonia which is turned into ammonium sulphate and tar. The sulphuric acid for the manufacture of the

ammonium sulphate is made in a recently installed contact process plant producing fifty tons of 100% acid per day.

So far the manufacture of benzol as a by-product of the coke ovens has only been attempted on a very small scale in India. A plant is now nearing completion at Jamshedpur for the manufacture of benzol and toluole for the Government of India. When it comes into operation, it will be of great assistance in the manufacture of high explosives for the ordnance factories. The plant is designed for extracting benzol motor spirit and toluole and is being installed by Messrs. Simon-Carves.

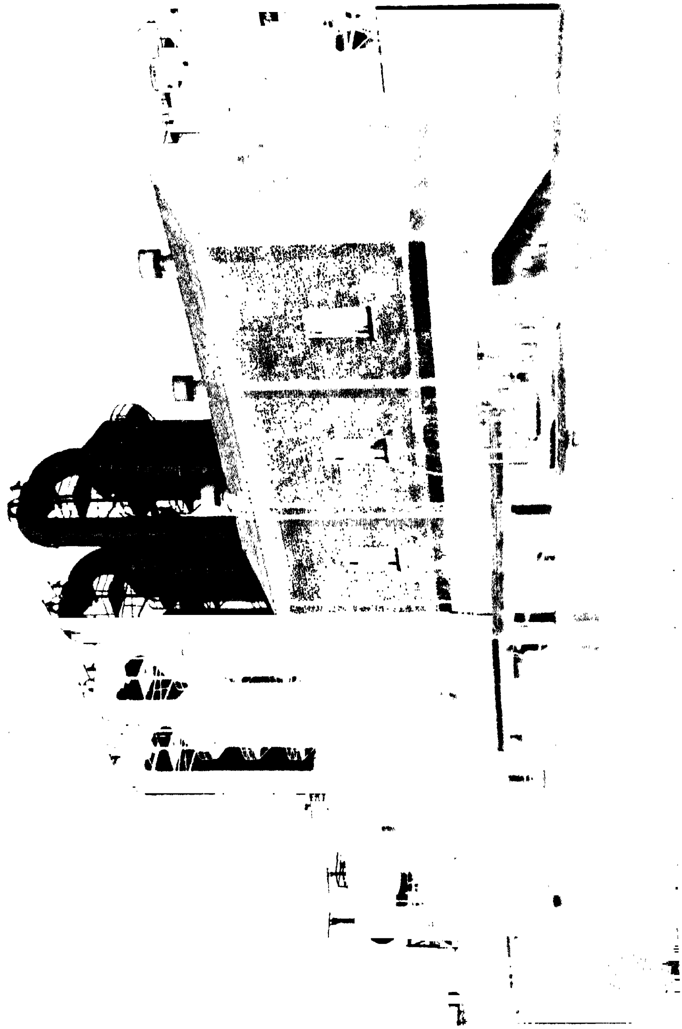
Blast Furnaces.

The next stage in the manufacturing process is the blast furnace for the production of pig iron. Ten years ago, Jamshedpur had four blast furnaces; two of the capacity of 900 tons, one of 750 tons and one of 250 tons per day. The small blast furnace was completely rebuilt in 1936 and its capacity was increased to 550 tons. An entirely modern blast furnace was installed last year. The diameter of its hearth is 22 feet 6 inches, of the bosh 26 feet 6 inches and of the top 19 feet. Its height is 95 feet and volume 35,160 cubic feet. For the one year that this furnace has been in operation it is estimated to have produced more iron than has ever been produced elsewhere on a furnace of similar size over a similar period. The total pig iron capacity of the Jamshedpur plant is a million and a quarter tons per annum.

For every ton of iron made, a blast furnace produces roughly 100,000 cubic feet of gas. This blast furnace gas contains about 14 grains of dust per cubic foot of gas at N.T.P. This gas has considerable fuel value, but owing to its dirty condition its use in industrial plants, such as blast furnace stoves and boilers is restricted. It has been realized that considerable fuel economy can be effected if this gas is cleaned. In the last ten years the Steel Company has installed two large gas cleaning plants, each with a capacity of fourteen million cubic feet of blast furnace gas at N.T.P. per hour. Both the plants clean the gas to a purity of 0·008 grains of solids per cubic foot of gas at N.T.P. The older of these two plants is the Lodge Cottrell plant of the dry type which came into operation in 1934. The second gas cleaning plant is of the Brassert design. This plant consists of wooden-hurdle wet washers which not only cool the dirty blast furnace gas but also remove about eighty per cent of the solids from the gas. This semi-cleaned gas is then passed through the Cottrell wet electric precipitators which precipitate the rest of the solids and deliver clean gas to specification.

Fuel Economy.

The old concepts of fuel economy and energy distribution have been completely revolutionized by the modern scientific use of coke oven and blast furnace gases. Fuel economy and distribution of energy in a large plant like that of the Tata Iron and Steel Com-



pany is a highly specialized job, which is in charge of a special department of the plant, designated the Energy and Economy Department. The efforts of this department have succeeded in reducing the overall fuel rate from 3·56 tons of coal per ton of steel in 1930-31 to 2·19 tons in 1939-40. Modern practice aims at reducing the use of coal as fuel and replacing it by the more efficient by-product fuels, such as coke oven gas, blast furnace gas, coke dust, etc. The use of mixed gases in this connection requires special mention.

The cleaning of the blast furnace gas permits of its use in coke ovens and releases a corresponding amount of the richer coke oven gas for use elsewhere at the plant. Blast furnace gas has a comparatively low heating value of about 110 B.T.U. per cubic foot of gas, while coke oven gas has a value of about 470 B.T.U. per cubic foot. Modern practice tends to a greater use of coke oven gas or a mixture of coke oven and cleaned blast furnace gas in steel making and re-heating furnaces, replacing to that extent coal which has been used so far in the form of producer gas. Fuel costs are thus greatly reduced. For the successful use of the gases it is necessary to have steady pressure of gas at the consuming ends. For that purpose two large dry gas holders for the storage of blast furnace and coke oven gas respectively have recently been installed. These gas holders act as reservoirs which smooth out the fluctuations of the gas caused by the furnace irregularities and thus assure continuous operation of boilers, coke ovens and other consuming centres. The blast furnace gas holder is a huge structure 283 feet high, 176 feet in diameter, capable of holding 5½ million cubic feet of gas at N.T.P. The coke oven gas holder is 192 feet high, 112 feet in diameter and holds 1½ million cubic feet of coke oven gas.

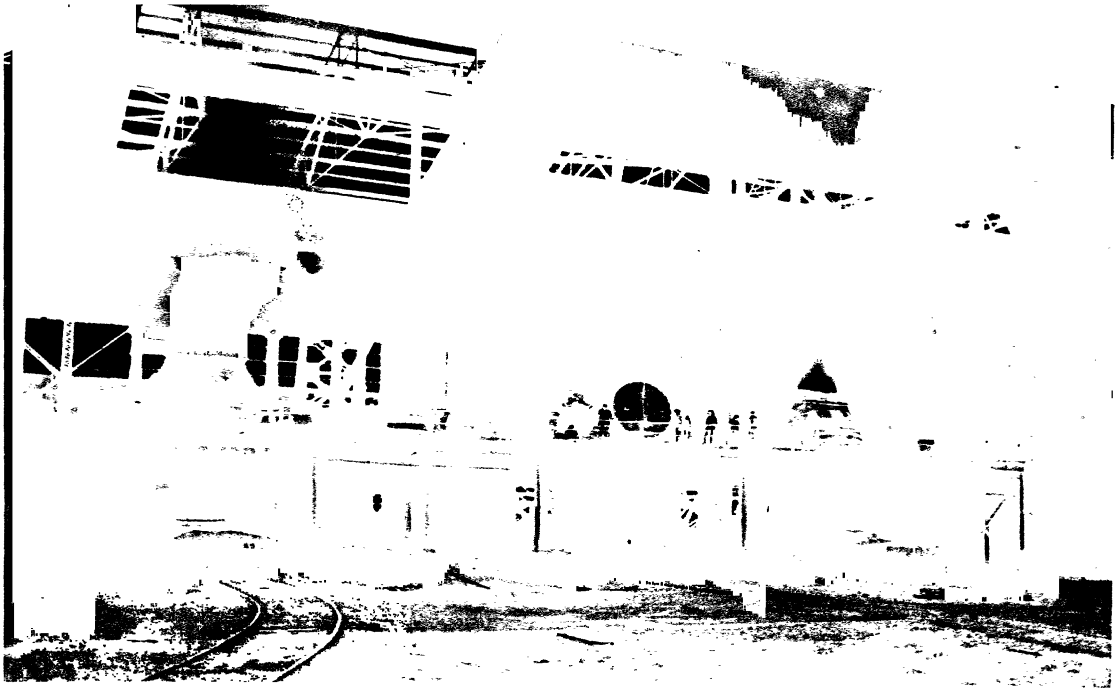
Steel-making Practice. The last ten years have also seen important developments in steel-making practice and a considerable increase in production.

Steel-making operations at Jamshedpur are carried out in two types of plants, the Open Hearth and the Duplex. The Open Hearth is the oldest part of the Jamshedpur plant. Four out of the seven furnaces which we were working ten years ago, have been remodelled along modern lines and an eighth furnace has been built. The ingot production from this plant has been increased during the last ten years by over 100,000 tons per year, the figure for 1929-30 being 242,000 tons as compared with 345,000 tons in 1939-40. The Duplex steel-making process, as its name implies, consists of two operations, (*a*) blowing the molten pig iron in acid lined Bessemer converters to remove the silicon and manganese and most of the carbon, and (*b*) transferring the blown metal to basic-lined Open Hearth tilting furnaces where the phosphorus is removed and the steel finished to chemical specification. Improvements to this plant during

the last ten years have resulted in increase of production from 340,000 tons in 1929-30 to 670,000 tons in 1939-40. In addition to these two steel-making plants a four-ton electric furnace was installed in 1936 mainly for the manufacture of electric castings, while two five-ton electric furnaces have only recently been installed and are being utilized for the manufacture of class steel, spring steel and alloy steel. The installation of these electric furnaces has been of the greatest assistance in the making of superior quality alloy steel required by the Defence Department.

A New Steel-making Process.

The most important advance made during the last decade, from the point of view of scientific research, is the practical development of the rapid dephosphorizing process. As this matter has never been the subject of public discussion in India so far, a few details will not be out of place here. As is well known, Indian pig iron contains about ·3 to ·4% phosphorus. This percentage of phosphorus in the iron neither lends itself to the straight basic Bessemer process nor to the straight acid Bessemer process. The phosphorus has to be removed to ·05% for most commercial specifications though as much as ·10% is admissible in certain products. The removal of this phosphorus is normally effected by the action of basic and oxidizing slags in Open Hearth furnaces. At the best of times this is a slow operation taking from one to several hours even in the quick working Open Hearth furnaces of our Duplex plant. In 1935, when our General Manager, Mr. Ghandy, and myself were on leave in Europe, our attention was drawn to certain developments in France, where a French Steel Engineer, M. Perrin, had carried out successful experiments in the rapid deoxidation of steel by violent mixing together of slag and steel so as to obtain a considerably greater area of contact between them than could ever be obtained in the conventional Open Hearth furnaces. This idea of the violent mixing of slag and steel was also considered applicable to the dephosphorizing operation. After a study of the French experiments, large-scale investigation over a long period was carried out at Jamshedpur and ultimately a practical method was evolved for operating the dephosphorizing process on a commercial scale under Indian conditions. This new process consists in blowing molten pig iron in an acid Bessemer converter to remove all the silicon and manganese and as much of the carbon as required. This blown metal is then poured from a considerable height into a synthetic molten basic oxidizing slag contained in a ladle. The metal comes into very intimate contact with the slag and the phosphorus is rapidly removed in the course of two or three minutes, instead of as many hours, in the normal open hearth process. As the steel and slag separate, the steel is finished to analysis and cast into ingots.



Bessemer Converters

The process is subject to exact control and steel of basic Bessemer quality can be made directly from the pig iron. Moreover, the dephosphorized metal can be further treated in an Acid Open Hearth furnace and steel of first class open hearth quality can be made. Thus for the first time in India it becomes possible to make acid steel out of Indian basic pig iron. A plant for the manufacture of steel by this process is now under construction. The successful development of this process may be regarded as the most important advance in steel making practice that the young Indian steel industry has made. It is likely to have far-reaching effects on the establishment of several new industries in India, such as locomotive manufacture and the manufacture of railway wheels, tyres and axles, for which acid steel is specified.

Rails.

In the manufacture of rails, advance has been made as a result of metallurgical research during the last ten years. Investigations have shown that medium manganese rails with a lower carbon and higher manganese content of 1·10 to 1·40% have superior properties of wear and resistance as compared to straight carbon rails with higher carbon and lower manganese content. There is a growing tendency to replace straight carbon rails with medium manganese rails. On the other hand, high chromium rails were found unsatisfactory.

An interesting advance has been the installation of Sandberg Ovens for the Sandberg controlled cooling process for rails. All over the world the controlled cooling of rails has come to be looked upon as a definite and desirable advance on the old practice of cooling rails on open hot-beds. The Tata Iron and Steel Company have obtained exclusive rights in India for the working of the Sandberg process. They have installed four Sandberg Ovens for the controlled cooling of their rails. Experiments are also being conducted in the welding of rails in the track. This aims at giving longer lengths in the track between joints and helps to provide a smoother ride.

Plates.

In the Plate Mill, the most interesting development in the last decade is the installation of a modern normalizing furnace for plates. This furnace was first installed to normalize some of the high tensile steel plates for the new Howrah Bridge. By the aid of this furnace it is now possible to produce in India normalized plates which had formerly to be imported. The furnace is also used to normalize certain structural sections. Thus materials with a new range of physical properties have been made available to the designing engineers. It is worth noting that Indian plates have largely replaced foreign plates even for the most exacting demands, such as for barges and ships.

Ten years ago, the Sheet Mill at Jamshedpur consisted of five hand-operated units and the total annual production was

38,000 tons. The rolling of sheets was an extremely strenuous manual operation calling for considerable physical exertion. Production was low, defects and rejections were high. To-day we have only four hand-operated mills and three mechanized units with an output of 170,000 tons. These new mechanized units have produced tonnages which, as far as can be ascertained, constitute a world record for this type of equipment. Besides the ordinary quality mild steel sheets, the Jamshedpur plant now turns out different classes of sheets with a high grade finish, including 'Tiscor' and high carbon sheets. Panel plates for coach building are supplied to the Railways and the various engineering firms. Other special developments in sheet manufacture are the rolling of drum stock for the manufacture of drums and containers, enamelling stock for deep-drawing and subsequent enamelling, furniture stock and, lastly, special sheets for steel helmets for the army.

Sheets.

It is owing to applied research that most of the significant advances in the steel industry at Jamshedpur during the last decade have been made possible. I have already mentioned the case of the rapid dephosphorizing steel. The development of low-alloy steels is another very important instance. Engineers in general and transportation engineers in particular are beginning to realize that ordinary carbon steel performs its functions only at the expense of unnecessary dead weight and excessive loss due to its low resistance to corrosion and abrasion. The problem of providing suitable materials for lighter weight is not one relating to mechanical strength alone. It requires the integration of several properties in one material, such as strength, resistance to impact, corrosion and abrasion, ease of forming, satisfactory welding, etc., as well as moderate cost. With this end in view, metallurgical research was conducted at Jamshedpur, resulting in the development and commercial manufacture of a low alloy, high-tensile steel containing copper and chromium known as 'Tiscrom'. This steel is being employed in the construction of the new Howrah Bridge.

Low-alloy Steels.

The introduction to India of another low-alloy high-tensile steel, sold in America under the trade name 'Corten' deserves mention. Research conducted in America had shown that the addition of a high percentage of silicon and phosphorus to alloy steel, containing chromium and copper, resulted in a low-alloy high-tensile steel of the same properties as those of Tiscrom but with the additional important property that it could be readily welded by all methods of rapid welding such as oxy-acetylene and automatic electric welding. After an investigation into the possibilities of the manufacture of this steel in India and an examination of the claims put forward for it, the Tata Iron and Steel Company obtained exclusive rights for

the manufacture and marketing of this steel in India under the trade name of 'Tiscor'.

Reference has already been made to the installation of the electric furnaces. Among the special qualities of iron and steel manufactured from these furnaces are chrome-manganese steel for crane track wheels, thirteen per cent manganese steel for crusher jaws and similar hard wearing parts of machinery, nickel-chrome heat-resisting steel and cast iron for various castings required to withstand high temperatures and nickel-chrome-molybdenum steel for crane pinions, mill rolls, etc. The manufacture at Jamshedpur of special alloy steel rolls has enabled the Steel Company to replace similar rolls of foreign manufacture.

Special Steels.

Since the outbreak of the war, intensive research work has been undertaken for Government in connection with the manufacture of armoured vehicles in India, and as a result a bullet-proof armour plate of special alloy steel which has stood the firing tests and has been accepted by Government, has been developed. Suitable steels for the manufacture of armour piercing shot and for steel helmets have also been produced. Research work was undertaken at the instance of Government in regard to the supply of steel suitable for telegraph wires. This steel has now been successfully manufactured and the wire rolled at the works of the Indian Steel and Wire Products out of this material has met with the approval of the Department of Posts and Telegraphs.

Researches are being carried out on behalf of the Defence Department in connection with the welding of chrome-molybdenum steel plates for aircraft manufacture and in other directions.

Most of the high speed steel requirements of the plant for machine tools are now being met by the remelting of tool scrap in the high frequency induction furnace in our laboratories. High chrome and stainless steels have been produced in the furnace in small quantities.

Besides metallurgical research, fuel research, chemical research and research in refractories are being pursued. Researches of the fuel department in blending and mixing have resulted in the determination of the most suitable varieties of coals for coking and similar purposes. Research on refractories has enabled us to evolve a better class of refractories for the use of the steel plant. Indian raw magnesite was at one time considered unsuitable for use in basic steel furnaces. Investigations carried out at Jamshedpur have now made it possible to produce in India the Steel Company's entire requirements of finished magnesite. Metal-cased magnesite bricks made at Jamshedpur have given very encouraging results for the superstructure of basic furnaces. Chrome magnesite brick for use above the slag line in basic Open Hearth furnaces in place of

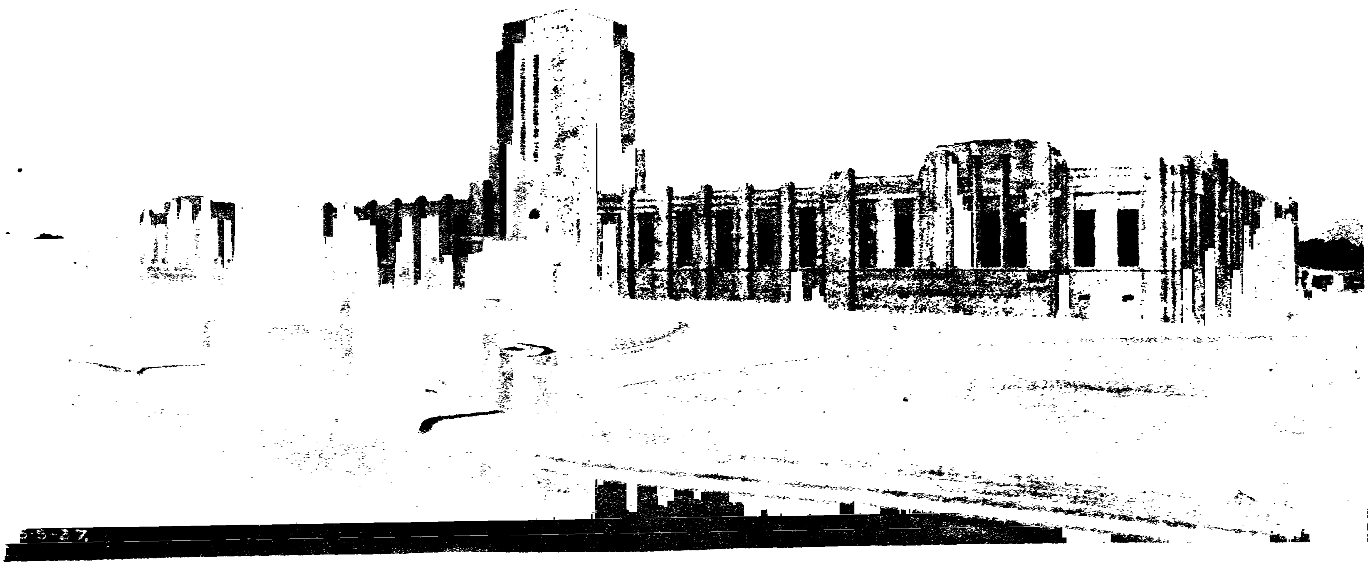
silica brick is another important development in the refractory field. Other interesting developments in brick manufacture are investigations into the possibilities of the manufacture of forsterite, semisilica, micaschist and mullite bricks. An entirely new process has been developed for the manufacture of mullite refractories using cyanite, silimanite and andalusite, India having practically a monopoly of the first two. Very productive work has also been accomplished with regard to high-temperature mortars. Superior types of mortars for high temperature work are now being locally made, replacing many of the imported brands.

To facilitate research work, a modern well-equipped laboratory was erected in 1937 at a cost of over Rupees ten lakhs.

A nucleus for a National Metallurgical Laboratory.

May I express the hope that with the facilities for metallurgical research provided by this laboratory and its workers, Jamshedpur may in the near future become the centre of a National Metallurgical Laboratory and Research Institute and thus be enabled to play a greater and worthier part in the development of the metallurgical industry in India.

When the titanic conflict now being waged ends, as end it must, in the triumph of the democracies and the cause of human freedom, I pray that India may emerge from it with the foundations of its industrial as well as political freedom well and truly laid, so that she may be properly equipped to play her rightful part in peace and in war as a worthy member of this great commonwealth of nations.



New Control and Research Laboratory

SECTION OF MATHEMATICS AND STATISTICS

President :— M. RAZIUDDIN SIDDIQI, PH.D., F.N.I.

Presidential Address

(*Delivered on Jan. 3, 1941*)

FUNCTIONAL ANALYSIS AND MATHEMATICAL PHYSICS

1. INTRODUCTION.

During the last 150 years mathematics has not only made an immense advance in the directions already indicated by Descartes, Newton, Leibnitz, Euler and Lagrange, but entirely new branches have been created, such as projective geometry and functions of complex variables in the pure, and mathematical physics in the applied domains. This development in mathematics has often gone hand in hand with the progress of the natural sciences. New methods of attack have been developed in order to solve the problems set by these sciences. The most famous example of this kind is the Fourier analysis developed in connection with the theory of Heat conduction. The recent development in the theories of integral and integro-differential equations owes its origin mainly to the occurrence of such equations in mathematical physics.

At times, however, the trend of events has been in the opposite direction. Many subjects in mathematics were developed purely for their own sake by the generalization of previous concepts. At the time of their creation they were considered to be so abstract as to be of no earthly use for any applications. But as our knowledge of the world advances, even the most abstract branches of mathematics are being found to be required for the explanation of the processes of nature. We have gradually seen the functions of complex variables, functions of an infinite number of variables, tensors, quaternions, matrices and groups become powerful tools in the hands of the physicist.

Mathematics is thus becoming more and more indispensable for all other branches of knowledge. The formulation of all the fundamental laws of nature requires its use. Dirac has recently pointed out that 'Mathematics is the tool specially suited for dealing with abstract concepts of any kind, and there is no limit to its power in this field. For this reason a book on the

new physics, if not purely descriptive of experimental work must be essentially mathematical.'

Another characteristic development of modern times is the rise of the deductive method in applied mathematics. Instead of advancing from particular cases to the general, as done in the inductive or historical method which prevailed up to the 19th century, mathematicians now sought for the most general and comprehensive law from which particular consequences could be deduced as necessity arose. Thus, to give one or two well-known instances, in mechanics instead of starting with Newton's laws and then generalizing them to Lagrange's and Hamilton's equations, mathematicians began to write down Hamilton's Variation Principle at the head of mechanics, and deduced all other results from it. Similarly, instead of building up electrodynamics inductively with the help of Coulomb's, Gauss's, Ohm's, Joule's, Ampere's and Faraday's laws, it was realized that the theory could be more effectively and logically constructed by assuming simply Poynting's law together with the principle of conservation of energy.

These attempts at the unification of various theories and various branches of knowledge demand the creation of very powerful tools of mathematical analysis. Such tools have been created and developed since the beginning of the present century, and it is of these that I would like to speak in this address.

2. The integral equation.

Gauss* was the first mathematician to be led to an integral equation through a boundary-value problem in potential theory. Later in 1823, Abel [1] was led to the equation:

$$\text{I.} \qquad f(s) = \int^{s} \frac{\phi(t)}{\sqrt{s-t}}\,dt, \quad f(0) = 0,$$

by a consideration of the following problem in Mechanics:

'To determine a curve in a vertical plane such that a heavy particle starting from rest and restricted to move on the curve, shall arrive at the lowest point O in a time which shall be a given function $f(s)$ of the initial height s above the point O.' With the help of Fourier's theorem, Abel showed that the solution of the integral equation (I) is given by

$$\phi(s) = \frac{1}{\pi}\int_0^s \frac{f'(t)\,dt}{\sqrt{s-t}}.$$

* D. Hilbert: Grundzüge einer. allg. Theorie der Integralgleichungen, Leipzig, p.l, 1912.

Independently of Abel, Liouville[2] was led to the integral equation (I) while studying an extensive class of geometrical and physical questions. One of his problems was as follows: 'An indefinite straight line Y has a uniform distribution of mass symmetrical with respect to the x-axis. It is attracted by the point A situated on this axis at a distance x. The attraction on each point of Y depends on its distance from A, but the law of attraction is not known. The total attraction $\psi(x)$ being given, determine the attraction $F(r)$ of the point A on the point M at a distance r from A'.

The considerations of Abel and Liouville gave rise to a vast number of inversion formulae for definite integrals. The integral equation which we now call of the second kind came up gradually in the course of the 19th century. Its first occurrence can be traced to Liouville (1837). A. Beer[3] found it again in 1856 in connection with a boundary-value problem of the potential theory. These were, however, integral equations with special kernels. It was Paul du Bois-Raymond[4] who, in 1887, first drew attention to the general equation:

$$\text{II.} \qquad \phi(s)+\int_a^b K(s,\,t)\phi(t)\,dt = f(s).$$

Incidentally, it was du Bois-Raymond who suggested the name 'Integral Equation' which was later adopted by David Hilbert. Before this the problem was called 'Inversion of a definite integral'.

Two methods of iterations or successive approximations were developed to solve the equation (II). Thus

$$\text{III.} \quad \phi_0(s) = f(s), \quad \phi_n(s) = f(s) - \int_a^b K(s,\,t)\phi_{n-1}(t)\,dt, \qquad (n = 1,\,2,\,\ldots.)$$

and

$$\text{IV.} \quad \begin{cases} f_1(s) = -\displaystyle\int_a^b K(s,\,t)f(t)\,dt, \\ f_n(s) = -\displaystyle\int_a^b K(s,\,t)f_{n-1}(t)\,dt, \quad (n = 2,\,\ldots.) \\ \phi(s) = f(s)+f_1(s)+f_2(s)+\ldots. \end{cases}$$

Liouville[5] was the first to use this method of solution for a particular equation of the second kind. The special nature of his kernel allowed him to prove the uniform convergence of $\phi(s) = f(s)+f_1(s)+f_2(s)+\,..$ by explicit calculation. A. Beer[6] applied the method (III) formally to his integral equation. His main contribution lay in the fact that he transformed an integral equation of the first kind which cannot be solved by the

method of iterations to an equation of the second kind which can thus be solved. The convergence of Beer's process was first established by C. Neumann [7], and the method of iterations is usually associated with his name.

Another class of integral equations, the so-called Volterra's equations, were first discovered by J. Le Roux [8] and Vito Volterra [9]:

$$\text{V.} \qquad \phi(s)+\int_0^s K(s,\, t)\phi(t)\, dt = f(s).$$

Volterra remarked that the treatment of equation (V) was analogous to that of a system of linear algebraic equations in which the rth equation contains the first r unknowns only.

At this stage came the epoch-making discovery of Ivor Fredholm [10]. Inspired by the work of H. Poincaré [11] in connection with Dirichlet's Problem, Fredholm introduced the general integral equation

$$\text{VI.} \qquad \phi(s)-\lambda\int_a K(s,\, t)\phi(t)\, dt = f(s).$$

He conceived the idea of treating this equation on the model of a system of linear algebraic equations which are solved with the help of determinants. Fredholm found the solution of (VI) as a quotient of two integral transcendental functions of λ. He followed faithfully not only the results but also the methods of the theory of determinants. Confining himself to these elementary operations and avoiding the function-theoretical considerations employed by Poincaré, Fredholm was yet successful in formulating a simple theory of quite a general character.

In complete analogy with the theorems for a system of linear algebraic equations, Fredholm proved the following two theorems:

Theorem 1. If $D(\lambda) \equiv \sum_{n=0}^{\infty} (-1)^n A_n \lambda^n = 0$, where

$$A_n = \frac{1}{n!}\int_a^b \cdots \int_a^b \begin{vmatrix} K(r_1, r_1), \ldots, K(r_1, r_n) \\ \cdots\cdots\cdots\cdots \\ K(r_n, r_1), \ldots, K(r_n, r_n) \end{vmatrix} dr_1 \ldots dr_n,$$

then the non-homogeneous equation (VI) has for any arbitrary and continuous function $f(s)$, one and only one solution $\phi(s)$, and particularly the solution $\phi = 0$ for $f = 0$. In this case the transposed equation

$$\psi(s)-\lambda\int_a^b K(t,s)\psi(t)\,dt = g(s)$$

has also a unique solution.

Theorem 2. If λ is a real root of $D(\lambda)=0$ of multiplicity p, then the homogeneous equation

$$\text{VII.} \qquad \phi(s)-\lambda\int_a^b K(s,t)\phi(t)\,dt = 0$$

has p linearly independent solutions $\phi_1(s)$, $\phi_2(s)$, ..., $\phi_p(s)$. Every solution of (VII) is then of the form

$$\phi(s) = c_1\phi_1(s)+c_2\phi_2(s)+\cdots+c_p\phi_p(s),$$

where the c's are constants.

The associated equation

$$\psi(s)-\lambda\int_a^b K(t,s)\psi(t)\,dt = 0$$

has also p linearly independent solutions $\psi_1(s)$, ..., $\psi_p(s)$. Every solution of this associated equation can be written as

$$\psi(s) = c_1\psi_1(s)+\cdots+c_p\psi_p(s).$$

The non-homogeneous equation (VI) for $D(\lambda)=0$ is then and only then soluble when

$$\int_a^b f(s)\psi_r(s)\,ds = 0, \quad (r = 1, 2, \ldots, p).$$

3. Hilbert's general theory of linear integral equations.

Immediately after the publication of Fredholm's first paper, the investigations were taken over by David Hilbert [11], who, during the decade (1901–1910), developed a fairly complete theory not only of the solution of linear integral equations, but also of eigenvalues, of the Fourier expansion of arbitrary functions in series of eigenfunctions and of application to mathematical and physical problems.

Hilbert started with the algebraic problem of the orthogonal transformation of a quadratic form in a sum of squares, and then arrived at the solution of the transcendental problem (for integral equations) by a rigorous application of the limiting process when $n\to\infty$. Hilbert established not only the existence of eigenfunctions in the most general case, but gave also the necessary and sufficient conditions for an infinite number of eigenfunctions. His investigations showed that it is not at all necessary to employ ordinary or partial differential equations in the theory of expansion of arbitrary functions. It is actually the

integral equations which form the necessary basis and the natural starting point for such expansions in series.

Hilbert's eigenvalue theory is developed on the same lines as the principal-axes theory of algebra, and if the functions are taken to be integrable L^2, the new theory becomes completely analogous to the algebraic theory.

Hilbert then considered the ordinary differential equation of the Stum-Liouville type

$$\frac{d}{dx}\left\{p(x)\frac{du}{dx}\right\}+\{q(x)+\lambda k(x)\}u=0,$$

for various boundary values, reduced it to an integral equation with the help of the so-called Green's function, and proved the existence of eigenvalues and the expansibility of the given functions in series of eigenfunctions of the problem. He proved a similar result for the self-adjoint partial differential equation:

$$\frac{\partial}{\partial x}\left\{p(x,y)\frac{\partial u}{\partial x}\right\}+\frac{\partial}{\partial y}\left\{p(x,y)\frac{\partial u}{\partial y}\right\}+\{q(x,y)+\lambda k(x,y)\}u=0.$$

A simpler and elegant method for obtaining Hilbert's results directly without using the limiting process was given later by Hilbert's pupil, Erhard Schmidt [12]. Two other of Hilbert's pupils, viz.: Hermann Weyl [13] and R. Courant [14] considered the maximum-minimum properties of the eigenvalues.

4. Applications of linear integral equations.

Integral equations have now become indispensable in many theories in geometry, analysis and the whole domain of mathematical physics. The theory of ordinary and partial differential equations, specially of the equations of mathematical physics, cannot be conceived without the theory of integral equations. The equations of heat, sound and of the potential theory, the oscillations of a linear system, the problems of heat-conduction and oscillation in two and three dimensions, thermoelastic phenomena of straight rods, and numerous other important subjects can be dealt with in a satisfactory manner only through the mediation of integral equations.

In many cases the same result can no doubt be obtained by solving a boundary-value problem for a differential equation, but the employment of integral equations has many advantages: (1) First of all in the differential equation there is an unnecessary splitting-up of the problem into the fundamental equation and the secondary conditions. The integral equation contains in itself all parts of the question. (2) Then it is not necessary to investigate individually problems of different higher orders with a different number of boundary conditions each time. The study of only one kind of integral equations is sufficient. (3) Again,

problems with a single independent variable and those with several independent variables give rise to the fundamentally different theories of ordinary and partial differential equations, whereas in the theory of integral equations there is no fundamental difference between the two cases. (4) Finally, it is seen that problems with several dependent variables which give rise to a system of simultaneous differential equations can be treated with the help of a single integral equation alone.

In problems of mathematical physics, the integral equation is usually obtained through the medium of an ordinary or a partial differential equation or of a system of such equations. In 1910, however, Hilbert [15] made a direct application of the theory of integral equations without bringing in the differential equations at all. He showed that it is a linear integral equation of the second kind with a symmetric kernel which forms the real mathematical basis of the kinetic theory of gases. A systematic formulation of the theory of gases would be impossible without the modern methods of integral equations. For want of an application of integral equations the theory of gases put forward earlier by H. A. Lorentz [16] was deficient, because Lorentz could not prove the existence and uniqueness of the solution of his fundamental equation.

Hilbert also proved that the theory of radiation, and particularly the well-known theorem of Kirchhoff about the relation between the emission and absorption of radiation, could be treated most simply and completely with the help of the theory of integral equations. It would be remembered that all proofs of Kirchhoff's theorem put forward before this were not quite satisfactory.

5. Integro-differential equations.

In classical mechanics and physics the fundamental problem is to explain the phenomena (i.e. to follow their evolution) and to predict them. If the system is known at a given instant, all future states are completely determined. Such an evolution which is known at each instant, and which therefore depends on external circumstances is called 'deterministic'. Thus, in the organic domain, the theories of Lamarck and of Darwin represent the type of deterministic evolution. In the inorganic domain, we have of course the Newtonian mechanics as an instance.

But evolution may depend on internal causes. If at each instant it depends on the actual conditions, it will be a non-hereditary evolution. Only one analytical apparatus, viz., the theory of differential equations, is necessary for the treatment of these non-hereditary phenomena, whether in the organic or in the inorganic domain. All these phenomena obey the principle that the present state determines the future. This principle is a consequence of the conception that each action manifests itself

only at the instant when it takes place, and leaves no heritage. This is the same thing as the assumption that the system does not conserve the memory of those actions which have affected it in the past.

Now, all the phenomena of nature are not really produced in this way. Heredity and memory do exist, but we neglect them to simplify the study of such phenomena. The classical hypotheses are only an approximation to reality. There are a number of phenomena which cannot be explained by the classical theories at all. The analysis proper to such phenomena is that of integro-differential equations.

We shall mention here a few instances where heredity plays a big rôle, and whose explanation requires the integro-differential equations.

(1) It is a fact well-known to engineers that the deformation of an old bridge is not the same at the present moment as it was at the time of its erection.

(2) Similarly, suppose that one end of an elastic horizontal bar is fixed, while different weights can be hung at the other end. First we go on increasing the weights and then take them off gradually. It is observed that the deformation of the rod for any given weight is not the same when the weights are being increased as it is when the weights are being diminished. Thus we see that the actual deformation does not depend only on the actual weight, but also on all the preceding weights.

(3) The phenomena of hysteresis in magnetism are evidently of a hereditary character; they are very important in electrotechnology.

(4) Webster [17] has considered the very interesting question about the best material for making tuning forks. He has been led to apply the conceptions of heredity and integro-differential equations to this problem, and to many others in acoustics.

6. Non-linear integral and integro-differential equations.

When Fredholm and Hilbert built up the theory of linear integral equations in close analogy with a system of linear algebraic equations, it was natural to enquire whether the theorems on a system of non-linear algebraic equations could not be carried over to non-linear integral equations. These considerations have, however, been carried out for the solution 'im-kleinen', that is, in the restricted domain, or, as they are sometimes called, for 'local solutions'.

Let

$$F_r(x_1, x_2, \ldots, x_n, y) = 0 \qquad (r = 1, 2, \ldots, n)$$

be a system of non-linear algebraic equations in n unknowns, where y is a parameter. Suppose, $x_r = a_r$, $(r = 1, 2, \ldots, n)$

is a known solution of this system for the parametric value $y = b$. We know from algebra that for those values of y sufficiently near to b, we can determine solutions of the system with the help of the solution $x_r = a_r$. The two main results in this connection are as follows:

(1) If the Jacobian determinant $\left|\dfrac{\partial F_p}{\partial x_q}\right|$ does not vanish for $x_p = a_p$ and $y = b$, then one and only one solution of the system exists.

(2) If the Jacobian vanishes, then we get Puiseux's theorems on the branching-off of the solutions for varying parameter.

The existence theorem 'im-kleinen' for non-linear integral equations of the type

$$\phi(s)+\int_a^b K(s,t)\phi(t)\,dt+\int_a^b H(s,t)\{\phi(t)\}^2 dt+\ldots.=g(s)$$

was established by Fubini[18], Volterra[19] and others by the method of successive approximations. Non-linear integral equations of Volterra's type have also been solved by this method for small values of a parameter λ entering into the equation.

E. Schmidt[20] developed in 1908 a theory for non-linear integral equations corresponding to Puiseux's theorem for algebraic equations. Schmidt considered the equation.

$$\text{I.}\quad u(s)+\int_a^b K(s,t)u(t)\,dt=v(s)+F\{u(s),v(s)\},$$

where F denotes a non-linear functional operation called an 'integral power series' by Schmidt. The functional $F\{u(s), v(s)\}$ consists of an infinite number of terms of the form

$$u(s)^{\alpha_0}v(s)^{\beta_0}\int_a^b\ldots.\int_a^b K(s,t_1,t_2,\ldots.,t_n)u(t_1)^{\alpha_1}v(t_1)^{\beta_1}$$

$$\ldots.u(t_n)^{\alpha_n}v(t_n)^{\beta_n}dt_1\ldots dt_n,$$

$$(\alpha_0+\beta_0\geqslant 0,\ \alpha_1+\beta_1\geqslant 1,\ldots.,\alpha_n+\beta_n\geqslant 1,\quad n\geqslant 0),$$

where $K(s, t_1, \ldots. t_n)$ is a continuous function of all its arguments in (a, b), and where all α, β and n are non negative integers. The problem is to solve the integral equation (I) for every given continuous function $v(s)$ whose maximum modulus is sufficiently small.

Schmidt proved that there are various possibilities for the solution of (I) according to the solubility or otherwise of the linear homogeneous equation:

$$\text{II.} \qquad u(s)+\int_a^b K(s,t)u(t)\,dt = 0.$$

(1) Suppose that (II) has no non-trivial solution. Then there exist two positive numbers h', k' such that for every continuous function $v(s)$ with $Max\,|\,v(s)\,| < k'$ there exists one and only one solution $u(s)$ of (I) such that $Max\,|\,u(s)\,| < h'$. This solution can be expressed as an integral power series in $v(s)$.

(2) Suppose that (II) has only one solution. Then we can find an integral transcendental equation

$$\text{III.} \qquad L_2x^2+L_3x^3+\cdots = F_1\{v(s)\}$$

in an unknown x with constant L_2, L_3, . . . , which can be found from successive integrations of known functions, and where F_1 is an integral power series in $v(s)$ which vanishes for $v = 0$.

Now, if L_n is the first non-vanishing coefficient of (III), then for each $v(s)$ with sufficiently small maximum, there exist exactly n solutions of (I), that is to say, there is a n-ple branching-off as in the case of algebraic equations.

However, if all L_n vanish, then for $v(s) = 0$, the equation (I) has a non-denumerably infinite number of solutions.

(3) In the third case, suppose that (II) has n linearly independent solutions. Then we get n branching-off equations of the type (III) in n parameters. Every system of sufficiently small solutions of these equations gives us a solution of (I).

A number of non-linear integral equations were also solved by Volterra [21] with the help of his theory of permutable functions and compositions and of his functional calculus. In fact, with the help of this calculus, he was able to show that every problem of analysis which has meromorphic functions for its solution leads to two problems which are correlated to it: (*a*) an integral or integro-differential problem of Volterra's type having integral functions for its solution; (*b*) a problem of Fredholm's type having meromorphic functions for its solution.

In connection with various problems in higher partial differential equations and in hydrodynamics and celestial mechanics, L. Lichtenstein [22] set up and solved a number of non-linear integral equations and integro-differential equations. For instance, he considered the equation

$$\text{IV.} \quad \lambda\phi(s) = \sum_{n=1}^{\infty}\int_0^{\pi}\cdots\int_0^{\pi} K_n(s, s_1, \cdots, s_n) \times \phi(s_1)\cdots\phi(s_n)\,ds_1\cdots ds_n,$$

and proved that at least for one value (zero included) of the parameter λ, the equation (IV) has a non-trivial solution. The proof is given by reducing to an existence problem in the calculus

of variations; from all functions continuous in $0 \leqslant s \leqslant \pi$ and satisfying

$$\int_0^{\pi} \phi^2(s)\, ds = \frac{\pi}{2},$$

it is required to determine those functions which give the highest value to the functional

$$U\{\phi\} = \sum_{n=2}^{\infty} \frac{1}{n} \int_0^{\pi} \cdots \int_0^{\pi} K_n(s_1, \cdots, s_n) \phi(s_1) \cdots \phi(s_n)\, ds_1 \cdots ds_n.$$

Lichtenstein proved similarly the existence of an eigenvalue and of a solution of the non-linear integral equation

$$\lambda\phi(t) = \sum_{n=1}^{\infty} \int_0^{\pi} g_n(s) K(s, t) \left\{ \int_0^{\pi} K(s, r)\phi(r)\, dr \right\}^{n-1} ds.$$

Solutions of some non-linear integral equations 'Im-grossen' i.e. non-local solutions, have also been given by J. Leray [23], J. Schauder [24] and L. Pomey [25].

The present speaker [26] has considered infinite systems of non-linear integral equations of the type

$$\text{V.} \quad u_n(s) = f_n(s) + \int_0^{s} g_n(s, t) F_n\{t, u_1(t), u_2(t), \cdots \infty\}\, dt,$$
$$(n = 1, 2, \cdots \infty),$$

and has developed methods for establishing the existence and uniqueness of the solution both in the restricted as well as unrestricted domains. The solution is determined by means of the successive approximations for each $n \geqslant 1$:

$$u_n^{(0)}(s) = f_n(s) \quad \text{and for } r \geqslant 1$$

$$u_n^{(r)}(s) = f_n(s) + \int_0^{s} g_n(s, t) F_n\{t, u_1^{(r-1)}(t), u_2^{(r-1)}(t), \cdots\}\, dt.$$

It is proved first that the series $\displaystyle\sum_{n=1}^{\infty} \left| u_n^{(r)}(s) \right|$

converges uniformly for all s and all r, and further that the double series

$$\sum_{r=0}^{\infty} \sum_{n=1}^{\infty} \left| u_n^{(r+1)}(s) - u_n^{(r)}(s) \right|$$

converges uniformly. Thus it is shown that these approximations converge to a unique limit $u_n(s)$ which is continuous and which satisfies the non-linear integral equation (V) for all n. With the help of this infinite system, the present speaker [27] has been able to solve various boundary-value problems for non-linear partial differential equations of the parabolic and hyperbolic types. Some cases of non-linear integral equations and integro-differential equations have also been investigated by Minakshi Sundaram [28], while working with the present speaker.

Levi-Civita's problem of the propagation of two dimensional surface waves of finite amplitude, Carleman's problem of the theory of heat radiation, specially the problem of thermal equilibrium in the presence of radiation, the problems of heat conduction in deep seas and in crystals are solved by reducing them to non-linear integral equations.

On the other hand, the regular two-dimensional variation problems, the inversion problem in the theory of functionals, the equilibrium figures of rotating fluids, the dynamics of incoherent gravitating media, the hydrodynamics of homogeneous frictionless fluids and a host of other problems [29] can only be treated with the help of non-linear integro-differential equations.

7. Functions of infinitely many variables.

The idea of passing from the finite to the infinite has always been extremely attractive and fruitful in mathematics. Its fundamental significance lies in the fact that through it we are led from algebra to analysis. Thus, to give but one instance, integration is nothing but the taking over of the conception of a sum from the domain of the finite to that of the infinite.

Many attempts to realize this conception and to apply it were made long before the present century. Daniel Bernoilli [30] treated in 1732-33 the oscillating string as the limiting case of a system of n oscillating particles. The principle of passing from the finite to the infinite was applied by Cauchy [31] for demonstrating the existence of integrals of differential equations. But no one understood its deep significance better than Riemann,[32] as can be judged from his remarks on the integration of partial differential equations of hyperbolic type.

For the further development of functional analysis, the introduction in 1886 of this principle into the theory of infinite determinants was of considerable significance. Up to this time some attempts were made to treat infinite systems of linear algebraic equations, but these attempts were not successful. Only when G. W. Hill [33], H. Poincaré [34] and H. von Koch [35] took over the question of infinite determinants and applied the principle of passing from the finite to the infinite, was it possible to build up a theory of solution of infinite systems of algebraic

equations whose theorems were completely analogous to those of n equations in n unknowns.

Thus originated the idea of the function of an infinite number of variables. It is to Hilbert again that we owe the systematic development of the theory of such functions. As we have already pointed out in § 3, Hilbert solved the integral equation by reducing it to a system of n algebraic equations and then making a passage to the limit $n \to \infty$. In this connection he introduced the function $F(x_1, x_2, x_3, \ldots)$ of an infinite number of variables, and developed an extensive theory of linear, bilinear and quadratic forms side by side with the theory of linear integral equations [36].

Hilbert did not confine himself only to the development of a theory of infinitely many variables, but he showed at the same time how the whole theory of solution and the theory of eigenvalues of integral equations can be deduced from it directly.

The connecting link between the integral equations and the equations in an infinite number of unknowns is an infinite system of functions $\{\phi_n(s)\}$ which are defined and continuous in the interval $a \leqslant s \leqslant b$, and which satisfy the following conditions:—

(1) the system is ortho-normal, i.e. for any m, n

$$\text{I.} \quad \int_a^b \phi_m(s)\phi_n(s)\,ds = \delta_{mn} = \begin{cases} 0 \text{ if } m \neq n, \\ 1 \text{ if } m = n\,; \end{cases}$$

(2) the system is complete, that is to say, for any pair of continuous functions $u(s)$, $v(s)$ the identity

$$\text{II.} \quad \int_a^b u(s)v(s)\,ds = \sum_{r=1}^{\infty} \left\{ \int_a^b u(s)\phi_r(s)ds \,.\, \int_a^b v(s)\phi_r(s)\,ds \right\}$$

is satisfied.

Now consider the integral equation

$$\text{III.} \qquad \phi(s) + \int_a^b K(s, t)\phi(t)\,dt = f(s).$$

Writing

$$x_n = \int_a^b \phi(s)\phi_n(s)\,ds, \qquad f_n = \int_a^b f(s)\phi_n(s)\,ds,$$

$$K_n(s) = \int_a^b K(s, t)\phi_n(t)\,dt,$$

$$\int_a^b\int_a^b K(s, t)\phi_m(s)\phi_n(t)\,ds\,dt = \int_a^b K_n(s)\phi_m(s)\,ds = K_{mn},$$

we get, on account of the completeness relation (II),

$$\text{IV.}\quad \sum_{n=1}^{\infty}\{K_n(s)\}^2 = \int_a^b \{K(s,t)\}^2\,dt;$$

$$\sum_{n=1}^{\infty} f_n^2 = \int_a^b \{f(s)\}^2\,ds,$$

$$\sum_{m=1}^{\infty}\sum_{n=1}^{\infty} K_{mn}^2 \leqslant \int_a^b\int_a^b \{K(s,t)\}^2\,ds\,dt.$$

Thus the equation (III) can be written as

$$\text{V.}\qquad \phi(s)+\sum_{n=1}^{\infty}K_n(s)x_n = f(s).$$

Further, for a continuous solution $\phi(s)$ of (III), the sum of squares

$$\text{VI.}\qquad \sum_{n=1}^{\infty}x_n^2 = \int_a^b \{\phi(s)\}^2$$

is seen to be convergent. Again, on account of Schwarz's inequality $\{\Sigma u_n v_n\}^2 \leqslant \Sigma u_n^2 \Sigma v_n^2$, it follows from (IV) that the series $\underset{n}{\Sigma} K_n(s)x_n$ is uniformly convergent in (a, b). Hence

$$\int_a^b \phi(s)\phi_m(s)\,ds+\sum_{n=1}^{\infty}x_n\int_a^b K_n(s)\phi_m(s)\,ds = \int_a^b f(s)\phi_m(s)\,ds$$

or

$$\text{VII.}\quad x_m+\sum_{n=1}^{\infty}K_{mn}x_n = f_m \qquad (m=1, 2, \ldots).$$

Thus we have the theorem that the Fourier coefficients x_n of every solution of the integral equation (III) give a solution of the system (VII) with convergent sum of squares.

If $f(s) \equiv 0$, that is to say, if the integral equation is homogeneous, then $f_n = 0$ for all n, so that x_n satisfy the system of homogeneous equations

$$\text{VIII.}\quad x_m+\sum_{n=1}^{\infty}K_{mn}x_n = 0 \quad (m=1, 2, \ldots.).$$

Conversely, if $x_1, x_2, \ldots$ is a system of solutions of (VII) such that $\underset{n}{\Sigma} x_n^2$ is convergent, then it follows that the series

$\sum_n K_n(s)x_n$ is uniformly convergent, and therefore the function $\phi(s) = f(s) - \sum_n K_n(s)x_n$ is continuous. Then

$$\int_a^b \phi(s)\phi_m(s)\,ds = \int_a^b f(s)\phi_m(s)\,ds - \sum_{n=1}^{\infty} x_n \int_a^b K_n(s)\phi_m(s)\,ds$$

$$= f_m - \sum_{n=1}^{\infty} K_{mn}x_n = x_m \quad \text{from (VII).}$$

This shows that x_m is the Fourier coefficient of $\phi(s)$, so that from (II) we obtain

$$\sum_{n=1}^{\infty} K_n(s)x_n = \int_a^b K(s, t)\phi(t)\,dt.$$

Thus we see that $\phi(s) = f(s) - \sum_n K_n(s)x_n$ is a solution of the integral equation (III).

Further, it is evident from (VI) that the Fourier coefficients of a continuous function all vanish only when the function itself identically vanishes. Thus, from a system of solutions of the homogeneous algebraic equations (VIII), we get solutions of the homogeneous integral equation. Also, a number of systems of solutions of the homogeneous algebraic equations is linearly independent only when corresponding solutions of the homogeneous integral equation are linearly independent. Finally we see that the transposed integral equation

$$\psi(s) + \int_a^b K(t, s)\psi(t)\,dt = g(s)$$

corresponds to the system of algebraic equations

$$x_m + \sum_{n=1}^{\infty} k_{nm}x_n = g_m \qquad (m = 1, 2, \cdots).$$

Thus the complete equivalence of the solution theory of linear integral equation (III) and that of the system of linear algebraic equations (VII) is established.

In 1914 Lichtenstein [37] made his well-known application of Hilbert's theory of infinite bilinear and quadratic forms. He developed a method of dealing with the boundary-value problems by reducing them directly to equations in an infinite number of unknowns without reducing them first to integral equations. In subsequent years this became a very powerful method for the treatment of such questions for ordinary and partial differential equations.

Hilbert and his pupils Hellinger [38], Toeplitz [39] and others considered in detail the 'Vollstetig' and bounded bilinear and quadratic form in an infinite number of variables, and developed in this connection a theory of infinite matrices and of principal-axes transformations. It was this last theory which supplied the mathematical foundations of modern, quantum mechanics [40]. An elaborate geometry of the Hilbertian space has also been developed [41]. Among its many applications we may mention the generalized absolute differential calculus which includes Ricci's calculus as a particular case.

8. The theory of functionals.

We have seen that both from the side of mathematics and from that of natural philosophy we are compelled to introduce the idea of functions of infinite number of variables. If we consider a natural phenomenon as the effect of a finite number of causes, we are making only an abstraction because we are neglecting elements which are supposed to be very small compared to others which are taken to be preponderant. In this way we make only an approximative study of the phenomenon for a full and complete examination of which it would be necessary to pass from a finite to an infinite number of variables. Thus, to take a general example, if a phenomenon depends on a physical field, and if the field, regarded as a continuum, is varied, then the changes of the phenomenon would depend on an infinite number of variables. Similarly, we have already remarked that in phenomena where heredity and memory of the past play a big rôle, it is essential to employ functions of infinitely many variables.

Let us consider an old problem of isoperimetry, viz. that of finding a plane curve of given length which encloses the greatest possible area. The area here is evidently a function of the enclosing curve, and since the curve can be represented as an ordinary function, the area can be considered as a quantity which depends on all the values of a function. It is therefore a function of an infinite number of variables. A more general example is provided by the integral

$$I = \int_a^b f\left(x, y, \frac{dy}{dx}\right) dx$$

which depends on all the values of the function y in the interval (a, b).

Thus the definite integral and the calculus of variations present the first two instances of the idea of a functional. But the credit of recognizing the individuality and the importance of this new conception in mathematics goes to Pincherle [42], and above all to Volterra [43]. The functional calculus was created

in 1887 when Volterra published his researches under the title 'functions depending on other function'. He changed the name later to 'functions of lines', but the term 'functional' which is now generally accepted was proposed by Hadamard. Thanks to the profound researches of Volterra, Hadamard and a brilliant congregation of other workers, the functional analysis has developed extensively, and has penetrated deeply into the various branches of pure and applied mathematics. Everything concerning integral, integro-differential, and functional equations, investigations on functional spaces, the calculus of variations in its broadest sense, questions involving effects of the hereditary type—all these different subjects have now been unified in one general theory of functionals. These different theories, viz. those of integral equations, calculus of variations, etc., then become only so many chapters in the theory of functionals. Moreover, the theory of functionals can be applied to mechanics, mathematical physics, biology, statistics and sociology.

Investigations on the theory of functionals can be divided into two main groups which are called 'functional algebra' and 'functional analysis'. The first consists of problems where the unknowns are ordinary functions, but which become a part of the functional calculus on account of the methods which are employed to solve them. To this category belong the theories of integral and of integro-differential equations. The second group, viz. that of functional analysis, consists of those problems in which the unknowns are functionals, or more generally of those problems which cannot be conceived independently of the notion of a functional.

It seems desirable to give a brief résumé of the precise meaning of the functional, and also of the fundamental notions of the calculus.

For the sake of definiteness, we consider the function $x(t)$ of a single variable t taken in the interval (a, b). The functional depending on the argument-function $x(t)$ is represented by the notation $U[x(t)]$ or simply by $U[x]$. In general the functional depending on the three argument-functions $x(t)$, $y(t)$, $z(t)$, and on two parameters λ, μ will be represented by $U[x, y, z; \lambda, \mu]$. As we have remarked the functional analysis appears as a natural generalization of the theory of ordinary functions, and can be deduced from the former by the method of proceeding to the limit. Thus, if we divide (a, b) into n equal parts, and if we represent the function $x(t)$ asymptotically by a function $X_n(t)$ which is constant in each of these intervals such that the constant value of $X_n(t)$ in the interval $\left(\frac{i-1}{n}, \frac{i}{n}\right)$ is denoted by x_i, then the functional $U[x]$ would be reduced for $X_n(t)$ to a function $u_n(x_1, x_2, \cdots, x_n)$ of n variables. Hence the

functional in such cases can be defined as the limit of the function $u_n(x_1, x_2, \cdots, x_n)$ when $n \to \infty$. Even if this procedure does not always provide a rigorous demonstration, it constitutes a remarkable method of induction for obtaining fundamental results of the functional analysis. Volterra calls this method 'the method of passing from discontinuous to continuous'.

Generalizing the idea of representing a function of n variables by a point in an ideal space of n dimensions, each function $x(t)$ is represented by a point $[x]$ in a space of infinite dimensions, which is called 'functional space'. A functional of $x(t)$ will then become a function of the point $[x]$. The notions of the bound, limit and continuity of a function can then be generalized to give analogous notions for a functional. There would be, of course, several definitions possible according to the definition which we adopt for the distance between two points $[x]$ and $[y]$ of functional space, representing the two functions $x(t)$ and $y(t)$. This distance is commonly defined as the number r, positive or zero, given by

$$\text{I.} \qquad r^2 = \int_a^b \{y(t)-x(t)\}^2\, dt.$$

The functional field in this case will consist of those functions whose square is summable. Other definitions of distance will give rise to other functional fields.

Fischer [44] and Riesz [45] have studied the geometry of this functional space, and have shown that it is remarkably similar to the geometry of n-dimensional space. Thus, consider an infinite system $\{x_n(t)\}$ of ortho-normal functions, and an infinite sequence $\{c_n\}$ of coefficients such that the sum $\sum_{n=1}^{\infty} c_n^2$ is finite. Fischer and Riesz have shown that the series

$$\text{II.} \qquad c_1x_1(t)+c_2x_2(t) + \cdots + c_nx_n(t) + \cdots$$

converges in the mean to a function $x(t)$ such that

$$\text{III.} \qquad \int_a^b x^2(t)\, dt = c_1^2+c_2^2+ \cdots +c_n^2+ \cdots$$

Conversely, if a function $x(t)$ can be represented by a series of the type (II) which converges in the mean, then the coefficients c_n are given by the formula

$$\text{IV.} \qquad c_n = \int_a^b x(t)x_n(t)\, dt.$$

The $x_n(t)$ can therefore be considered as unit vectors in a rectangular co-ordinate system in functional space. Then $x(t)$ would

be the vector from the origin $x(t) \equiv 0$ to the point $[x]$ representing $x(t)$, whose length l would be given by $\left\{ \int_a^b x^2(t)\, dt \right\}^{\frac{1}{2}}$. The Fourier coefficient c_n would be the component (length of projection) of $x(t)$ in the direction of the unit vector $x_n(t)$. The relation (III) would then be only the expression of the Pythagorian Theorem

$$l^2 = \sum_{n=1}^{\infty} c_n^2.$$

9. Different branches of the functional analysis.

Functional analysis has been studied and developed along various lines corresponding to those of the theory of ordinary functions.

A functional $U[x]$ depends on the argument-function $x(t)$ which can be taken to define a line. If one point of the line is altered, we get what is called a 'derivative' of the functional. Supposing such modifications of a line made at all its points we obtain a 'differential' or 'variation' of the functional. We can then pursue the study of successive differentials, and then arrive at an analytic development analogous to that of Taylor. Then we can try to find the maxima and minima of a functional. This will necessitate an investigation of the conditions under which the differential of a functional would vanish. These investigations are very much difficult and complicated, and much work remains to be done in this respect.

If we consider the various terms in the Taylor expansion of a functional, we are led to analytic forms in an infinite number of variables, thus giving rise to a new algebra closely connected with the ordinary algebra. In the first place each chapter of the ordinary algebra leads to a corresponding problem obtained by Volterra's principle of passing from discontinuous to continuous. At the same time this correlation offers us in the majority of cases practical and easy solutions, because these new problems can be considered as limiting cases of the problems of ordinary algebra. Very often the solutions are only limits of the known algebraic solutions. A well-known instance of this is provided by the general theory of an infinite system of linear equations.

The theories of functions of several variables and of multiple integrals have also been generalized to give corresponding theories in functional analysis. A theory of functional derivative equation has been built up by Hadamard [46] and Levy [47], to correspond to the theory of differential equations. The functional derivative equations consist of relations between the functional derivatives of a functional, the functional itself and the independent variables. These equations can also be obtained

by the usual process of passing from the finite to the infinite, from ordinary total differential equations, and from partial differential equations.

10. Applications of the Theory of Functionals.

The first application of the functional analysis was made to the calculus of variations with the help of Volterra's extension [48] of the Hamilton-Jacobi theory. We know that this theory plays an important rôle in the integration of the equations of mechanics. It has its origin in the fact that the differential equations of mechanics are nothing but the Euler equations of an Extremum problem concerning the action integral. It is well known that many other problems of mathematical physics can be reduced to problems of the calculus of variations. In the development of the science of Physics, there has often been a tendency to reduce natural problems to the question of finding a minimum. This has been due to the conviction that Nature, in its manifestations, tends to accomplish various phenomena at the lowest possible expenses. The problems of mathematical physics thus depend on the extremum of a multiple integral, making it necessary to consider the integral as a functional of the field of integration. It would then be impossible to obtain a generalization of the Hamilton-Jacobi theory without the aid of the functional analysis.

Volterra [49] has insisted on this point from the very beginning of his researches. He has pointed out, for instance, that Hamilton's principle can be developed in two different directions: the so-called principle of stationary action and the principle of variable action. It is the latter that requires the theory of functionals. In it, the action is considered as a function of the final values of the integrals and of the time, so that for a continuous system with an infinite number of degrees of freedom the action becomes a function of an infinite number of variables, and therefore a functional. 'It follows that the extension of the principle of variable action to the cases of electricity, magnetism, elasticity and so on, and in general to the classical questions of mathematical physics, leads to a corresponding series of principles which cannot be enunciated without the terminology of functionals, and which find their development within the sphere of the theory of functionals'.

Shortly after the appearance of Volterra's first researches, Hadamard [50] Tonelli [51] and others applied these conceptions to obtain direct and rigorous methods for treating questions of the calculus of variations. These questions consisted mainly of the following three successive steps:

(1) To obtain the equations which express the vanishing of the first variation. These are the well-known equations of Euler.

(2) To determine the lines or surfaces which verify Euler's equations and which satisfy the boundary conditions of the problem, or at least, to establish the existence of such lines and surfaces.

(3) To investigate whether these lines or surfaces really give a maximum or a minimum.

Now in the classical method of the calculus of variations it was always easy to write down Euler's equation, but the other two questions, and specially the third, presented great, almost insurmountable difficulties. Functional analysis has made the direct investigation of these questions quite easy, and has thus given new life to the calculus of variations.

These investigations have contributed greatly to bring about a unification of the whole structure of mathematical physics. Moreover, the new method gives us a ready criterion for examining whether the various expressions for natural laws are in an invariant form agreeing with modern relativistic conceptions. The employment of a variational form for the expression of a physical law makes the change of variables easier, so that we can conveniently investigate the invariance of our equations for a change of the frame of reference. The direct method is often employed in the modern theories of physics as an instance of which can be mentioned the quantum-electrodynamics proposed by Heisenberg and Pauli [52].

Another field for an application of the functional analysis is provided by the celebrated principle of Dirichlet, and similar existence theorems. This principle postulates the existence of a function continuous along with its derivatives in a domain D with the boundary S, taking given values on S and making the integral

$$I = \iint_D \left\{ \left(\frac{\partial \phi}{\partial x}\right)^2 + \left(\frac{\partial \phi}{\partial y}\right)^2 \right\} dx\, dy$$

a minimum.

The corresponding Euler equation is Laplace's equation of the potential theory, viz. the equation

$$\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} = 0.$$

We have thus to find a continuous solution of this equation which takes given values on S. This is called Dirichlet's problem. Similar remarks can be made for the solutions of boundary-value and eigenvalue problems of linear partial differential equations of elliptic type.

Gauss and Riemann believed that the existence of the function $\phi(x, y)$ was assured because the integral I was always

positive. Weierstrass raised an objection to this assumption, and gave simple examples of minimum problems which had no solution. This method of proof was then abandoned and efforts were concentrated on solving Dirichlet's problem, i.e., on finding a solution of the differential equation for the given boundary conditions. Various methods, viz. those of Neumann [53], Schwarz [54], Poincaré [55] and Fredholm [56] were developed to solve the problem, but these had no connection with the calculus of variations.

Then, inspired directly by the theory of functionals Arzela [57] tried to go back to Dirichlet's principle, and attempted to give a rigorous proof of the existence of the minimum under certain conditions. It was Hilbert [58] who, in the year 1900, furnished such a rigorous and complete demonstration of Dirichlet's principle, and obtained a definite result with the help of the theory of functionals. The work has been subsequently continued by Levi, Fubini, Lebesgue, Zaremba and various other writers [59].

The idea of treating the integral and integro-differential equations as chapters in the theory of functionals was already mooted out by Volterra [60] in 1913. Subsequent developments have revealed the close connection between these two subjects. The general methods employed today for treating the integral equations in all their generality are effectively the same as those which have served for making a passage from ordinary functions to functionals. In both cases, the basic concept is a systematic and uniform application of the principle of passing from discontinuous to continuous. The powerful theories of integral and integro-differential equations, with all their applications to geometry, analysis, mechanics and mathematical physics, are thus found to be only branches of the still more powerful theory of functionals.

The method of functionals and particularly of integral equations has been applied by Proudman [61], Matteuzzi [62] and others to the study of the oscillations or tides of lakes. This phenomenon was first observed in the lake of Geneva, where, owing to its elongated form, the changes of level sometimes reach a couple of meters. Extending a method used by Lagrange for the theory of the vibrations of strings, Proudman divides the lake into an infinite number of narrow strips, and studies their vibrations, making use of infinite determinants. Matteuzzi, however, applies the general theory of integral equations, and obtains all the results directly. The same method has been applied by Poincaré [63] and others to the study of the problem of oceanic tides.

In 1914 Volterra [64] suggested that functional analysis should be applied to the study of continuous systems, and especially those consisting of swarms of corpuscles not connected by links that can be expressed by means of differential relations.

G. C. Moisil[65] carried out this suggestion. He attached a set of functions which can be considered as co-ordinates, to each configuration of a continuous and variable system. Choosing a suitable metric for the functional space, and applying the tensor calculus, he arrived at differential equations analogous to Lagrange's equations in classical mechanics. The theory has a practical application in the study of the movement of a flexible and inextensible wire.

Volterra and his co-workers[66] have made an extensive use of functionals in the theories of elasticity and of hereditary phenomena in elasticity, electro-magnetism and mechanics. The theory of functionals has recently been applied to ballistics,[67] political economy,[68] statistics,[69] and to a biologico-mathematical theory of the fluctuations of species living together[70].

11. The general analysis of Frechet and Moore.

We have seen that the independent variable of the functional analysis is not numerical, as in the ordinary theory of functions, but a line, a surface or a function. From 1904 onwards Frechet[71] and Moore[72] began generalizing the analysis by discarding the concrete variables and considering those of any nature whatever. They proposed to extend the infinitesimal calculus to the case in which the nature of the variables is not specified. Not only was the numerical variable generalized, but the numerical function was replaced by a function of an arbitrary nature. Thus Frechet and Moore studied the relations between two elements of an abstract type. This subject is called 'general analysis' and has developed a great deal in recent years. This new analysis proceeds by making an abstraction of all those concepts which are common to several known and allied theories. These theories are then generalized by removing from them any particular properties that are related to the concrete elements on which they are based. A familiar example of this passing from the concrete to the abstract is provided by the concept of a vector which is the generalization of the concrete notions of velocity, accelleration, force, momentum, etc.

General analysis is not concerned with special cases of classical mathematics. Thus it does not deal either with functions continuous in an interval as is done by the theory of integral equations, or with the points of a n-dimensional space as is done by the algebraic theory of systems of n-linear equations, or with points in Hilbert space as is done by the theory of functions of an infinite number of variables, but with elements of an abstract aggregate. Its theorems contain those of integral equations as well as of finite and infinite systems of algebraic equations.

General analysis has not only given us several new subjects such as the theory of dimensions and topology, but it has also brought about a unification of various results in the classical theories. Thus the theory of integral equations becomes a particular case of the theory of transformations in abstract spaces and their inversions.

12. The theory of functional operators.

With the introduction of the idea of abstract spaces in analysis, we can easily pass over from the special theory of functionals to the general theory of operators.

The term 'functional operation' signifies any operation carried out not on numbers, but on functions.

Let E_1 and E_2 be two spaces formed of any elements whatever, provided only that the associative law of addition and the zero element are supposed to be defined in them. Let $y = U(x)$ be a function (operation, transformation) which connects an element y of E_2 to every element x of E_1. The functional is only a particular case of the operator U when E_2 is the space of real numbers.

If for any two elements x_1, x_2 of E_1, the relation

$$U(x_1+x_2) = U(x_1)+U(x_2)$$

is satisfied, the operator $U(x)$ is said to be 'additive'. If, further, E_1 and E_2 are metric spaces, i.e. if in each of them the distance between two elements is defined, the operator $U(x)$ is called 'continuous'. An operator which is additive and continuous is called 'linear'. Familiar instances of operations are those of differentiation and definite integration considered by Leibnitz [73] and later by Lagrange [74] and others [75]. Similarly, the ordinary complex numbers can be interpreted geometrically as transformations of a coplanar set of vectors, and are thus linear operators. So also, the quaternions as defined by Hamilton, are operators on three-dimensional vectors. These can be generalized further to n-dimensional operators.

A symbolic form of the operator calculus was developed and used by Heaviside [76] in connection with his researches in electro-dynamics. Giorgi [77] and others applied Heaviside's methods to the solution of numerous problems in mathematical physics, and to the integration of differential equations.

But the principal development of the operator calculus, so far as concerns linear functional operations in the field of analytic functions, is due to the work of Pincherle [78]. It was extended in various directions by Volterra [79], Calo [80], Bourlet [81] and a host of other workers [82].

The theory of operators has now become an essential part of many of the most important domains of mathematics. We have seen that the theory of integral equations and the calculus

of variations are contained as particular cases of the theory of functionals, and therefore of the general theory of operators. In this theory, we see the methods of classical mathematics blending harmoniously with those of modern mathematics. It gives us completely new interpretations of many results in the theory of sets or in topology. Thus, for example, Birkhoff and Kellog have demonstrated that by means of the theory of operators the topological theorem on the invariant point can be translated to give the classical existence theorem for differential equations. The operator theory brings about a certain unity in different branches of mathematics sufficiently remote from each other. For instance, the theorem on the continuation of an additive functional resolves simultaneously the general problem of measure as well as the problems of moments and of existence of the solution of a system of linear equations in an infinite number of unknowns. Thus a really profound insight into many important branches of mathematics such as the theory of functions, integral and integro-differential equations, calculus of variations, theory of sets, topology and theory of dimensions, is possible only with the help of functional operators.

On the other hand, modern theories of physics make much use of the operator theory. Thus, apart from classical mechanics and electro-dynamics, the subject of quantum mechanics in its modern developments is based entirely on the theory of linear operators. This theory plays the same part in quantum mechanics as tensor analysis plays in the theory of relativity. Quite recently the quaternionic operators have been applied to relativistic quantum mechanics [83].

It is well known that many of the laws of quantum mechanics are not in a covariant form. For instance, the uncertainty relation is not invariant for transformations of the Lorentz group. The non-covariance of quantum mechanics is due to the fact that in it, as in the classical theory, time plays a particular rôle, viz. that of the parameter. This is contrary to the relativistic idea that all the co-ordinates of space–time have the same status. For the mathematical description of physical phenomena, the world-point (x, y, z, ict) should be taken as parameter. The quaternions are admirably suited for this purpose. The application of quaternions has the advantage that it conserves the four-dimensional character of physical quantities all along the calculations. The q-numbers and the c-numbers of quantum mechanics thus become quaternions. The dynamical variables are therefore not simply Heisenberg's matrices, but quaternionic matrices.

The fundamental relations of quantum mechanics such as the Ritz combination principle, the quantum conditions, the equations of motion and Heisenberg's uncertainty relations, can then be generalized in a quaternionic form in the same way as

Dirac's relativistic equation is a generalization of Schrödinger's wave equation. Dirac's equation itself can be obtained from the quaternionic mechanics with the help of the most general Lorentz transformation. The relativistic quantum mechanics thus becomes a mechanics of the quaternionic matrices.

The theory of functional operators is playing an increasingly important rôle in the whole domain of mathematics and its applications. We can readily agree with Hadamard when he says that it 'is one of the most powerful tools of research in contemporary mathematics'.

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SECTION OF PHYSICS

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Presidential Address

(*Delivered on Jan. 4, 1941*)

THE RÔLE OF APPLIED PHYSICS IN INDUSTRY.

I would like to present before you all, some particulars of the subjects with which I have been intimately associating myself during the last few years. I have been feeling for some time that time is now ripe to consider the important rôle which the scientists of our country have to take up in associating themselves with the industrial development of our motherland. It would be necessary for us to take into account and to realise that in the last fifty years applied physics has exerted a more powerful beneficial influence on the intellectual, economic and social life of the world than has ever been exerted in a comparable time by any other agency in history. Its main sub-divisions, such as applied heat, applied optics, applied acoustics, applied electricity and magnetism, and applied mechanics, illustrate its scope. Anything we know about these subjects and whatever uses are made of such agencies as light, heat, electricity or the different materials in their different states fall within its field and are the contributions of applied physicists to human welfare.

Average citizen and man of the world have little comprehension regarding applied physics, since all the different people whose life-work really happens to be applied physics do not call themselves by that name. There has been a very interesting trend in applied physics by which great branches of its specialised interests have been appropriated by special groups of applied physicists who call themselves engineers as soon as a systematic method for the application of its principles has been developed in special fields. Thus we have civil engineers, mechanical engineers, electrical engineers, automobile engineers, aeronautical engineers, communication engineers, mining and metallurgical engineers, illumination engineers, motion picture engineers, radio engineers, chemical engineers and diverse others whose activities are wholly or largely concerned with the application of physics to practical ends. Considering 'Civil Engineering',

which is one of the oldest examples of applied physics, one finds that its field is based on the strength of materials, hydraulics and applied optics. Others like the radio engineering and motion picture engineering are based on discoveries within our lifetime. Turning our attention to metallurgical engineering, a very old practice, and the more recent chemical engineering involving important applications of the chemical science, it is easy to notice that the bulk operations are based on those applications which form the elements of mechanical engineering.

Besides these applied physicists, who group themselves as engineers, one finds astronomers, meteorologists, opticians and optometrists and many similar groups, who deal with physical instruments and theories in their special fields of activities. Hence it would not be too much to state that the economic, social and intellectual influence of applied physics is based on the contributions to knowledge, to industry, and to the art of living which have all emanated from the diverse elements which are but manifestations evolved from the knowledge of physics. Furthermore, one is cognisant of the fact that new knowledge and applications are rendered available more rapidly than ever before.

Let us try to explain our position a little more clearly and let us treat it under three different categories. Firstly, those industries which are based more upon ancient art which has been developed largely by practical experiences. In this category one finds such activities as the construction of buildings, highways, bridges, and dams; the production of metals, alloys and textile materials; the use of natural resources, such as power from wind and water, coal and oil. In all these fields there is an art which has been handed down from antiquity and which has been more or less improved by invention and discovery of new materials and methods. In these fields there is noticed a tendency for misunderstanding and conflict of ideas between the so-called practical workers on the one hand and the scientists on the other. The practical men have a great force of tradition behind them and the general public has a feeling of conservatism to oppose the introduction of new materials and new technique supplied by the scientists. The trend towards the scientific attitude is, however, unmistakable and is augmented partly by force of competition and examples, set up by more enterprising members. The second category embraces those industries which have been built upon more recent scientific discoveries. In this, one finds communications, air transportation, motion pictures with sound and colour accompaniments, illumination and the generation and diverse utilisations of electric power. It is noteworthy that since these industries have been created by research, the organisations, which are taking part in their introduction, would tend to become obsolete as soon as the research activities are allowed to diminish in vigour. The

third category includes those groups whose activities rest on the basis of other sciences, such as, chemistry, biology, etc. Here one finds the chemical industries, the industry of drugs and medicine which though not directly derived from physics but to which it is contributing an ever-increasing assistance through tools and measuring instruments, methods and interpretative concepts In the field of medicine, the X-ray has been marvelously developed for diagnostic examination and for therapeutic treatment of certain glandular disorders and growths, notably cancer. In the most recent developments primarily for investigations of atomic nuclear structure there is a bye-product exciting new suggestions for medical application. X-rays at a million volt or more have been finding applications for treatment of deep-seated cancer. Neutrons produced in nuclear transformations have been found to produce effects different from X-rays or radium and suggest advantageous application in modern therapy. Artificially produced radio-active preparations offer interesting possibilities for treatment and open up avenues for a great variety of new physiological investigations on a number of lines, such as blood circulation, tissue building and disintegration and the function characteristics of various organs of human and animal bodies. In physical therapy the application of high frequency diathermy and bloodless surgery is but one example of the application of forces studied by applied physicists and applied by the medical practitioner. The application of heat agency in the discriminative destruction of germs and growths is one of the newest forms of physical therapy which operates on the different threshold principle based on resistance and temperature. Quite recently an improved technique is being developed which consists in raising the body temperature locally by means of electromagnetically produced high frequency currents within the body in the region to be treated while the rest of the body is kept within safe limit by special cooling. Finally, it is not an idle boast to state that all the measuring instruments beginning from the thermometers to the portable cardiographs and the multitude of other devices are but the gift of applied physicists to the science and practice of medicine.

I shall now place before you some of the specific industries and would indicate how applied physics is instrumental in their development and growth. In this selection I shall take up first 'Building Industry' and 'Metal Industry' as representatives of a class having age-old traditions behind it. I shall next take up 'Electrical Power Industry' which has been effective in revolutionising all the modern industries, then 'Refrigeration Industry' which is the direct outcome of laboratory investigations. From the modern industries I shall choose 'Automobile Industry' and 'Aeronautics Industry', the last being the youngest

of the lot and still in the adult stage requiring constant help *from researches in applied physics.*

Building Industry.

Here one finds that all our structures built to date, rest on earth and a fairly large part of the world's construction cost is in working the earth; yet through the centuries the very bottoms of our buildings have been designed on an empirical basis. It is only very recently that the investigations regarding soil mechanics have been undertaken. The first International Conference on Soil Mechanics and Foundation Engineering held at Harvard University in the summer of 1937 has disclosed a wealth of outlook and previous lack of understanding of some of the essential aspects of the subject. The problems arising under soil mechanics in connection with design of foundations, the stability of cuttings, though manifestly of the greatest concern to the civil engineers and contractors, have had to be treated empirically in the past owing to the absence of reliable scientific knowledge. For the most part, the formulae used for estimating the behaviour of soils have involved such drastic assumption as seriously to impair their validity for anything like general application, and it has not been difficult to prove by systematic experiments to demonstrate that such relations as Coulomb's Law, for instance, are, to say the least, unsatisfactory. The analytical approaches to soil mechanics suggested by Petterson, Terzaghi, Jurgenson and others appear to be far more promising than any of the old methods. The so-called bearing values of the major soil types embodying an accumulation of practical experience, obviously took no account of numerical factors influential in particular set of conditions and were uncertain to a degree and often demanded uneconomical factors of safety and expensive procedures of foundation design. The modern approach to this class of problem seeks rather to understand the mechanism by which settlement occurs, to take account of variations in the type, depth and thickness of the soils in adjoining localities and underlying strata, and to place the effects of weather and secular changes on a rational basis.

At the present time an essential part of research on the subject is to obtain 'settlement records', as they enable correlation with the theory to be made and the types of settlement to be classified. From the experimental work so far undertaken it has been found that there are three types of settlement depending on the nature of the substratum. In the case of sand, the movements do not continue for any appreciable time after the construction, whereas for clay, the settlement continues for a long time after construction approaching a horizontal asymptote. With plastic clays and materials of high organic content a similar gradual settlement is noted, but here the asymptote

is inclined. The settlement of a building with clay as the most important substratum may be quite small at the end of the construction, yet the final or total settlement may be many times greater. The procedure adopted for settlement analysis consists of the following. Firstly, the cores of the various substrata are obtained with a well-boring kit and for large structures one has to take the cores up to a depth of 50 ft. The second step is to ascertain the consolidation characteristics of the samples so obtained by laboratory tests. The consolidation characteristics were first studied by Terzaghi with the help of the special instrument devised by him and called oedometer. In the instrument the sample of core material of definite thickness is placed in a brass cylinder between two porous stones which are in contact with water. The conditions of saturation and lateral restraint are thus simulated in the laboratory. Now, clay has an open microstructure as has been found from X-ray studies, but the dimensions of pores are very small and the resistance to flow is correspondingly high Under compression the clay as a whole can suffer volume decrease mainly by the escape of some water from its pores until an equilibrium density is established. Theoretically this would take infinite time but in the laboratory such a stage is attained in about two days. By gradual increase of pressure similar consolidation process takes place and a new equilibrium density is reached. A number of such data gives the relation between the density and effective pressure. This is technically denoted as the void ratio for the material in question. Thirdly, a mathematical analysis of the stresses set up in the substrata by the foundation load is carried out. The theoretical aspect is that of finding an expression for the vertical stress at any point in a semi-infinite elastic solid due to a load on its surface. This has been worked out by Boussinesq as early as 1885. In order to arrive at the rate of consolidation one has to take account of the hydrodynamic excess pressure 'w' in the pore water causing a flow at a distance 'z' from the surface of drainage after a time 't' from that of the application of the load and also the coefficient 'c' of consolidation. The fundamental equation has a general nature as $c\dfrac{\partial^2 w}{\partial z^2} = \dfrac{\partial w}{\partial t}$. If the degree of consolidation 'μ' is known from the data of compression at a time 't' and the total compression where μ is the ratio between the two aforesaid quantities, one can solve the differential equation in the form $\mu = f\left(\dfrac{\text{[illegible]}}{4d^2}\right) = f\,(N)$, where '$d$' is the maximum drainage path. The relation between μ and N has been evaluated for a number of special cases by Terzaghi and Fröhlich with the help of data secured with oedometer. Now, for any value of 't', 'N' is known from the laboratory tests and 'd' from the

boring records; the time settlement curve for any part of building structure can be predetermined. It is, therefore, possible to design a foundation with a measure of certainty not possible with the older empirical methods.

The paramount conclusions of the new work may be concisely stated as follows:—(1) The strains in a foundation which principally determine settlement and soil reaction extend at least to a depth equal to about twice the lesser horizontal dimension of the super-structure. (2) The depth of the foundation below the surface level has an important effect on the distribution of strains in the soil below it. (3) The pile driving formulaе are valueless for computing pile capacities in plastic soils owing to the fact that the side friction (which is the main support of the static support in such materials) is temporarily eliminated by water lubrication during driving. (4) The settlement in plastic materials and those containing organic constituents in some proportion is not uniform under uniform loading but tends to be greatest in the middle of the loaded area. (5) Compressibility of the soil materials depends on the initial arrangement, size and shape of the structure and grains as well as on the water content. For fine grained materials compression occurs very slowly and may take many years to complete owing to the water being retained in the pores. Its nature can be understood from micro-structure examinations and suitable laboratory experiments on samples of materials in an undisturbed state. (6) The shearing resistance of granular materials depends on the stresses in the contained water and their ability to escape from the structure. (7) The lateral pressures of granular materials are affected to an enormous degree by small motions of the retaining surface within the mass itself so that arching may entirely modify the pressure and its distribution. (8) The existence of rather deep-lying strata of compressible materials may have decisive effects on the surface structures specially, if there be means for the escape of water from them by pumping.

The applications of these ideas have been tested in some of the structures designed and constructed within the last two years and it has been found to be very satisfactory.

It is expected that structural engineers and designers of our land are conversant with this new outlook of their subject and a systematic and co-ordinated effort should be undertaken by the engineers and the applied physicists to determine the particulars for the type analysis of the underground soils. One could easily note that such analysis is of extreme importance in alluvial tracts where the soil characteristics are of varied nature and the calculations based on older concepts would lead to uneconomic procedures leading to uncertain results. The question of design of sub-base structures is getting more and more into prominence due to their need for cold storage, safe

deposit vaults and due to the urgent necessity created by the grave international situation for air raid shelters and one cannot overlook the need and urgency of these investigations as they form integral parts of the super-structures.

I shall just touch on brick building which is an ancient art and prehistoric in origin. The recent outlook on the subject would be interesting. Though the strength of bricks as derived from different types of clay and fired under different conditions has undergone considerable investigation, yet their surface resistivity is only being investigated quite recently. Here the technique of surface reflection, photometry and X-ray analysis has disclosed the porous nature of the surface layers and their effective resisting capacity against weather conditions. The moisture creeping factors of the bricks, by absorption through porous materials as sand plasters, have been the subject of investigation in a few laboratories and have disclosed considerable variation depending on the nature of grain structure and their transformation during the firing stage.

Metal Industry.

I shall now present before you the aspects of another industry which ordinarily appears to have very little to expect from applied physics. I mean the 'Industry of Metals'. Historically, it is more than a probability that the first metal industry was entirely one of applied physics. If as many archaeologists and historians believe, gold was man's first industrial metal, it was recognised by its colour, and its high specific gravity was used as a basis for its separation from the lighter rock-materials. The 'panning' operation is prehistoric in origin. It is, however, used prolifically even today, not only in the prospecting for gold but also for many other heavy minerals, for example, tungsten, uranium, copper, lead, thorium and a large number of sulphides. The operation is indeed based on the application of Stokes' law for the fall of sphere through a viscous medium. In its simplest form, the law states that under the action of gravity a sphere in a viscous medium fairly quickly acquires a constant velocity which is greater in a given medium, larger the sphere and the greater the difference in density between the sphere and the medium. In ore concentration, the pieces of rock are not spheres and the modification due to the shape has to be taken into consideration and has been investigated in some of the mining and ore separation institutes. The development of ore concentration machines, such as classifiers, jigs, shaking and riffled concentration tables, all take into account the modification of the above-mentioned law in its different modified forms. In the 'ore flotation' process, there is the application involving surface tension and adhesive phenomena. It is well known to mining profession that certain minerals, such as

sulphides, have greater adhesion for gas bubbles or for oil than for water. Most gangue rock, like silica, shows more adhesion for water and still more for acidified water. A mixture of sulphide particles and gas bubbles and gangue particles in a solution may result in the bubbles attaching themselves tenaciously to the sulphides until the average specific gravity of the ensemble is less than the solution and one gets the paradox—viz., that heavy minerals float. The preparation of froth, which helps to offer large surfaces for adhesion, has been the aim of these separators and various reagents for froth formation have been introduced from time to time. Quite recently this question of surface adhesion and surface layers has engaged the attention of physicists and the nature of ore surfaces are being investigated with ore microscopes and electron diffraction to elucidate the aspects of surfaces.

If one considers other ore concentration methods, one finds that they could be classified either as pneumatic, magnetic or electrostatic methods and all of them are essentially based on physical principles.

Turning our attention to the smelting operations, one finds that chemistry and physics work simultaneously in many phases. The separation of the slag from the metal is a purely physical process but chemical changes continue to function up to and after ingot pouring. In the furnace itself, there is continual heat exchange. The flow of gases under different temperature and reaction conditions is really regulated by physical laws. In the present practice of separation of flue dust from the blast furnace one finds an important application of applied physics. The magnitude of the operation would be realised from the fact that for each ton of pig iron, near about five tons of blast furnace gas have to be treated, containing flue dust which is eight to ten per cent of the weight of pig iron and the world production of pig iron for 1938 is more than 100 million tons. The device adopted for the purpose utilises first and second laws of motion as well as Stokes' law. The gas from the top of the blast furnace is allowed to enter a big chamber from the top and the velocity of the incoming gas flow is much reduced. It no longer can carry the same amount of dust suspended in the stream to be mechanically carried along with it. Most of the flue dust is projected to the bottom of the chamber which, after due sintering, is recharged into the blast furnace. Quite recently, when the laws relating to the eddy currents in air and stream-line shapes were being investigated for the design of zeppelin bodies, it attracted the attention of an American blast furnace designer and he utilised the principle by attaching a stationary stream-line shape in the path of the incoming high velocity blast furnace gas. The gas hits this stationary surface at a speed of about forty miles an hour and the shape is so designed that the speed is reduced to about four miles per hour and the eddy currents

are so far reduced that efficient separation of dust could be secured without any extra expenditure of energy. This new idea of stream-line has been utilised in the metallurgical operation. Further purification of the gas is effected by proper washing, where high surface energy of water particles in drop form acts as dust catchers. For still further purification electrostatic precipitation process is utilised. This electrostatic precipitation process is well known to applied physicists, as due to property of ions to act as nucleus for the attachment of fine materials whether in liquid or solid state. It is in principle the same as one finds in Wilson cloud chambers. The industrial use of this principle was first introduced by Sir Oliver Lodge and as a result, one finds the extensive application of the Lodge Cotterel process in the metallurgical industries to separate solid particles from smelter smoke either to make the smoke less objectionable or to recover the valuable flue dusts or both.

In the foundry, most of the operations are based on physical principles. One finds the temperature conditions suitable for casting operations, the nature of the fluid heads, the properties of surface wetting, the viscosity of the molten materials and the frictional flow of the hot liquids. All the abovementioned factors are regulated by laws actually discovered by applied physicists and have been appropriated and have become integral part of the art of foundry.

The theoretical understanding of the nature of metals necessitates a close examination of their structures as well as the lattice constants. From the industrial point of view, the system iron-carbon is the basis of materials with remarkable properties. It is further well known that pure iron undergoes modification with temperature, in four successive stages α, β, γ, δ, as its temperature is raised from cold to its melting point. In reality, these fall under two categories, namely, body-centred and face-centred cubic lattice, and α, δ belong to the first type and γ belongs to the second. The β modification is not due to a change in the structure but indicates a change from the ferro-magnetic to the paramagnetic state. Now considering the alloys, pearlite is a combination of soft ferrite and hard cementite. One finds that the mechanical properties of unhardened steel could be attributed to this. Austenite is the solid solution of carbon atoms in iron and Martensite is the glass-hard constituent of steel formed by quenching. For a long time its character was a matter of difficulty to metallurgists and it has been recently noticed that this form is due to a composite alloy of a definite lattice form. The nature of 'prison-bar' steel in which the hard core, formed of chromium steel, happens to be surrounded by a sheath of mild steel, also indicates a peculiar structure formation due to heat-treatment. The mechanical properties of different structures formed by iron and carbon are now being correlated with the theoretical

ideas concerning the strength of materials. Theoretically the force required to break a test piece of steel or any other material in tension should be thousands of times larger than what is observed in practice. In trying to explain this anomaly, one has to consider two types of materials, namely, the brittle and the ductile. In the case of brittle material, the failure is due to the fact that it never gives way simultaneously across the whole of its section as one has to assume in theory. In fact, the parting of the crystal starts at one place and proceeds across it since this stress is due to local intensification at the edge of the growing crack. Most probably a sub-microscopic crack in the material is the starting point from which this tearing process begins. In fact Griffith has shown the existence of ultra-microscopic cracks formed on the surface of vitreous silica when one touches it with the fingers; though the material when freshly prepared possesses very great strength if it is kept uncontaminated from external agencies. A ductile material, on the other hand, yields to stress. It is distorted as if the atomic planes are able to slide over each other like a pack of cards. This type of plastic flow is well known from the behaviour of a single crystal of a metal in the form of a rod which could be pulled out to several times its length by a very small force. In a general way one finds why metals in a state of purity are ductile whereas complex structures such as intermetallic compounds are in most cases brittle. Atoms of a metal are not held together by bonds and so long as they are in close packing, many configurations may be possible. A distortion equivalent to a glide plane may take place without any serious disturbance of any one of the atoms. On the other hand, in a compound having complex pattern a large amount of movement has to take place before any re-arrangement of the pattern is possible. The material will not yield as no intermediate stages can occur and it will rather break than yield.

Now, considering the subject of other alloys, one finds by taking the metallic elements two by two, the possibility of building up a very large number of alloys. There is a striking difference between the structures produced by alloying two metals than those obtained by the combination of two elements. One could note that to form a chemical compound the products should be present in definite ratios whereas in a binary alloy, each phase constitutes an intermetallic structure extending over a range of composition. When examined by means of X-rays, each of these intermetallic phases is found to have its atoms arranged in a definite manner, some may be of the body-centred cubic, others may belong to the face-centred cubic types. In the chromium-aluminium system which has recently been worked out by the X-rays method, phases are so numerous that eleven successive notations are required to designate them.

The extent of the phases can be determined by the consideration of the free-energy of the alloys as obtained by X-ray experiments. The free-energy has to be minimum for the system to be in equilibrium

$$F = U - T\phi$$

gives a relation between the free energy F, internal energy U, the temperature T, and the entropy ϕ, of the system. The limits of the various phases can be ascertained from a plot of the free-energy values of an intermetallic system against the composition. Even in the case of ternary system, this method has been extended by Bradley and Taylor who determined the phase boundaries of the iron-nickel-aluminium and other similar systems.

The question of phase patterns has been studied by Hume Rothery in considerable detail. His rule enunciates that in similar phase patterns, there is the same ratio of free electrons to atoms. As examples one could cite the case CuZn, a body-centred cubic structure, the ratio of electrons to atoms being 3·2 or 1·5. In brass this ratio is 1·62; though this rule has been found on close examination not to hold invariably, one may state that it is true in majority of cases. In order to have a general survey of the whole field of alloys, regarding their structure and properties, X-ray examination of the structure combined with consideration of free energy would lead to a better understanding of the nature of alloy-formation. Then, there is the question of the order and disorder change occurring in some of the alloys in the solid state when they are cooled from high to low temperature. X-ray analysis shows in the case of the alloys of copper and gold having Cu_3Au as formula, the arrangement of the face-centred cubic lattice is a random one at high temperature, the position being occupied without any regularity by the gold atoms. On slow cooling through a certain critical temperature, however, it is found that the atoms of gold travel to the cube corners and copper atoms to the face-centres and an orderly arrangement is set up. The iron-aluminium alloy of the composition, Fe_3Al, also exhibits this order and disorder change. One might conclude that since the ordering force can be destroyed by temperature, the forces are weak in alloys. Quite the reverse phenomenon has been observed in some alloy systems in which certain atoms pass out of the lattice with the fall of temperature and are disposed of by segregation. The ternary compound of iron-nickel-aluminium, Fe_3NiAl, is found to be homogeneous at high temperature but when slowly cooled it is found to contain isolated clots or groups of iron atoms. This alloy has been extremely useful as the constituent material for powerful permanent magnets.

A very interesting application of the properties of solid solution between two metals, one of which is in a liquid condition and other in a solid state, is technically known as the process of 'wetting'. The boundary layer, where such solution actually is formed, shows definite characteristics of an alloy formation. This process has been utilised in the manufacture of electric contacts when a tungsten disc is welded to a steel shank. An intermediary thin disc of copper is placed on the top of each steel shank, the tungsten disc being placed on the top of the copper. The ensemble is placed in a furnace with a hydrogen atmosphere until the copper melts. It is found that copper in a hydrogen atmosphere tends to wet both the tungsten and the steel. In fact under the temperature condition, namely, about 1100°C, an adherent of copper and steel is first formed on which the tungsten disc appears to float. With a slight rise in temperature, nearly about 1250°C, the wetting action of tungsten and copper begins. At first the tungsten disc moves about on the surface of the molten copper in an irregular fashion. But as soon as the process of solid solution of the tungsten in copper starts, discs of tungsten align themselves so that they remain centrally on the top of the molten liquid. This formation of the solid solution along with the effect of the capillary forces is also utilised in the manufacture of the welding electrode materials technically known as Elkonite. Powdered tungsten is pressed into briquets and moderately heated but not sufficiently to close the pores. It is then placed in molten copper in a hydrogen atmosphere. Capillary forces cause the copper to fill the pores even above the level of liquid copper, and on cooling one can get the electrode elements sufficiently hard and durable.

Another example of this type of alloy formation is found in the recent manufacture of cemented carbide tools for the machine tool industry. Tungsten carbide first obtained by Moissan is a very hard crystal. The crystal aggregations are porous in nature and brittle due to the existence of sub-microscopic cracks between them. Shrotter and Strauss tried to utilise this property of alloys and found that cobalt in a hydrogen atmosphere has the wetting property for the carbide. They compressed together powders of cobalt and tungsten carbide in a suitable mould and subjected them to moderate pressure. These were then put into an electric furnace with a reducing atmosphere and the temperature raised above the melting point of cobalt. They found that cobalt and tungsten carbide form a suitable matrix which retains the hardness quality of tungsten carbide intact. The material behaves more like diamond than like a metal. This has led also to the utilisation of the carbides of tantalum, titanum and molybdenum. These extremely hard crystals are soluble in each other in a wide variety of proportion at temperatures approaching their melting points. Even at 2000°C, the wetting properties and the

solubility are quite high. The solid solution indicates properties different from those of constituent carbides. Tungsten carbide with 6% cobalt bond will easily scratch sapphire and inferior only to diamond in hardness. One can have an idea of its hardness from the fact that whereas high speed steel with 18% tungsten contents has the Brinell number 800, that of the carbide with cobalt bond varies from 1400 to 2000. Its compressive strength is 500,000 lb/sq. cm. It has negligible coefficient of expansion, practically half of invar steel and it is practically non-magnetic. Wide variety of application has been found for these carbides, namely, as substitute for diamond dies, for wire-drawing industry and for valves and valve seats of pumps. The only difficulty about the material happens to be that it is incapable of being machined and can be only worked with suitable grinding devices.

Now I would like to present before you just another application of a technique, developed by applied physicist, opening up possibilities for a rapid quantitative determinations of the different ingredients of ferrous and non-ferrous alloys, I mean, spectroscopy. It is well known that as far back as early eighties of the last century Hartley first made a systematic study for the purpose. His work on beryllium and cerium indicated that when these elements are present in a matrix or body of other materials in small and decreasing quantities, its spectral lines gradually grow weaker and disappear in a definite order. Though Pollock and de Gramont demonstrated the utility of this technique, it remained ignored and forgotten till recently. The first lead in the subject was from the workers of the spectrographic laboratory of the National Bureau of Standards, U.S.A., in 1922, when Burns, Meggers, Kiess and Stimson showed that given proper attention, this method leads to fairly accurate results. W. Gerlach in Germany started a systematic investigation to enquire into the different factors necessary to get a correct interpretation of results. The present practice is based on his observations, namely, the adoption of an internal standard in the material to be investigated. A selected pair of lines, one from the major and the other from the minor constituent of the material in question at a definite ratio of the constituents, is selected. With the gradual diminution of the minor constituent the intensity of the line undergoes diminution in a definite fashion, and it is thus possible to arrive at a fair estimate of the percentage of the minor constituent. Furthermore, he found that there are homologous pair of lines in the spectra which have equal intensity under definite percentage ratios of the two elements. Within the last six years more than hundred workers are engaged in the subject and fairly large amount of literature has now been secured. Not only has the technique been efficiently adopted in many of the large metallurgical establishments in America and Europe but also

its importance has been instrumental in its adoption by the different ammunition and ordnance factories. In the routine analysis of the different constituent, for example, of the admiralty brasses in England, it has been found that 0·0007% of bismuth could be accurately estimated taking copper lines as the internal standard lines.

Electrical Power Industry.

I shall now consider 'Electrical Power Industry', an industry, little more than half a century old and is the direct outcome of physical research. The activity of Michael Faraday may be described as being repeatedly and continuously manifest on a large scale, in most varied manners, giving demonstrations of his law of electromagnetic induction. Magnetic fields in iron link electric current in coils, in generators, motors and solenoids in endless profusion, all over the world. The first electrical engineers were the great applied physicists,—Kelvin, Weber and others. The common electrical units volt, ampere, ohm, henry, farad, watt with one exception, are named after the renowned applied physicists.

I shall try to limit my subject by considering only the generation and distribution of power and exclude from it utilisation or conversion of electrical into other forms as light, heat, or electro-chemical processes. I shall treat, however, the field of communication which also transmits electrical power but at higher frequencies. In this restricted field I shall deal first with an aspect of physical investigation, which has come to the fore-front recently, viz., the 'Electric Discharge in Gases'. One meets this phenomenon practically at every point starting from the generation and leading up to the final utilisation circuits, sometimes serving very useful purpose and some other times as a disturbing factor leading to the failure of electrical circuits. The extent of the subject can be realised from the consideration, viz., that the present practice of power generation begins with the direct production of alternating current from about 11,000 to 33,000 volts. This voltage is then stepped up by transformers to a value suitable for transmission over short or long distances ranging from 22 to 287 kilovolts; this last value being used for transmission across a distance of 240 miles. For transmission system of intermediate high voltage, one finds it ranging from 2·2 KV to 6·6 KV for local distributions. For domestic and industrial utilisation circuits the voltage would be from 110 to 600 volts.

Let us begin with the alternating current generator with its exciter provided with a commutator and brushes for the generation of direct current to excite its field. Here one finds commutators depending for its proper functioning on the discharge between the brush and the receding commutator segment.

Further, one finds that the corona discharge in the minute air space between the insulated coil and the slots creating troublesome factors for the generator design. Next is the power switch, which functions by means of an arc between separating electrodes. In the oil circuit breaker, one finds the formation of the arc in a gas bubble formed by the decomposition of the oil. One has to alter the shape and disposition of the bubbles so that a short arc may be capable of performing its task of current interruption.

Let us now consider the transformer. In the design of its components, one has to reckon its different members, viz., the coils, core, the bushings and everywhere one finds devices whereby the baneful effects of discharge may be safeguarded.

In the transmission lines, as a serious disturbing factor one encounters the high voltage heavy current discharge-lightning. This has led to the provision of the lightning arrester, a device to produce protecting discharge to counteract the damaging effect of the lightning. Its spark-gap has to initiate the discharge and also to co-operate with other elements of the arrester in terminating the discharge after the passage of the lightning. Here the major tool for studying such problems is the cathode ray tube and the guiding element is the theory of ionisation in gases promulgated by the physicists. The modifications necessary in Townsend's theory to meet the conditions of high pressure and high breakdown voltage have been worked out by physicists but it was Rogowski, who after detailed series of investigations, indicated the need for the modifications. In the recent introduction of the 'protective tube' type arrester the spark gap is so ingeniously designed that the discharge passes down a tube made of fibre. The heat of the discharge decomposes some of the fibre into gas which passes through the discharge at such pressure and velocity as to extinguish the power arc at the instant when the current reaches the zero value. The flow of power through the conductor of the transmission lines is due to the magnetic and electric fields surrounding it. One has to avoid the formation of corona discharge from the conductors due to the overstressing of the air surrounding it. The nature of corona discharge has been the subject of study by applied physicists and engineers and still there remains a considerable amount of empiricism which could only be satisfactorily understood by their joint efforts.

It will be pointed out in the next section how different types of dielectrics are being requisitioned to avoid the harmful effect of these discharges. In the low tension circuits, the power fuses have to be designed to suppress arc formation. In a recent type, boric acid has been introduced to supply steam in small quantities sufficient to check the arc.

Considering the conversion of A.C. power to D.C., one finds the introduction of an arc formation device through the mercury

vapour. The mercury arc rectifiers have been rapidly replacing the dynamic type of machinery for conversion purposes in railway, industrial and electro-chemical processes. Here, the cathode spot in the mercury pool is kept in an excited state by the maintenance of a discharge to it from an auxiliary electrode or other main electrodes. In the 'ignitron' type of mercury arc tube, which is now finding industrial application, one finds a stationary rod of high resistivity material dipping into the mercury pool. It has been possible to produce at the junction, a concentration of electrical field and current flow, similar to that which occurs at separating contacts, leading to the formation of the cathode spot of an arc. In this tube the stability is maintained by placing the anode directly in the path of the vapour stream coming from the cathode spot. Tanberg observed that the vapour coming from the cathode spot at low pressures has an extraordinarily high momentum and energy corresponding to more than hundred volts. Such high velocity stream formation, though at first doubted by some, has now been confirmed and one can now understand it as due to multiple ionisation of the atoms.

Incidentally, one is led to consider the discharge phenomena in low pressure devices such as the 'thyratrons' and 'grid glow tubes'. Here the heated thermionic cathode provides the available electrons when a proper potential difference is applied, Here the formation of the plasma suggested by Langmuir satisfactorily accounts for the development of the discharge. In the low pressure gas tubes, there is a curious limit to the magnitude of the current that can pass through it. This sets a limiting value to the current depending on the pressure. When this value is exceeded, a kind of instability sets in, due to which, the discharge is sharply interrupted and re-established repeatedly in an erratic fashion. This has also been accounted for as due to a high degree of ionisation in the gas and it has been suggested that the effect is due to pumping of a high vacuum by the motion of the positive ions.

Let us next discuss in a general way some of these applications in power systems and find the problems common to them. Looking from this aspect one finds the initiation of the useful discharge, then their proper termination and finally the prevention of restarting after the current has attained zero value.

The initiation of discharge in switches and commutators takes place so simply and so spontaneously by the mere operation of separating contacts and the problem of terminating the discharge is frequently so difficult that one does not appreciate the useful function performed by it. If, however, one considers the fundamental aspect of Faraday's law, one finds that the very existence of the power system depends upon it. Without this device sudden high voltage will develop if the current is actually reduced to zero value quickly at the moment of separation

of the contacts. This moment is to be synchronised with the instant of the zero current value of the alternating power so that the electrostatic capacity of the system can absorb energy and thus avoid the dangerous high voltage formation. In general however, the capacity is so small that a very close synchronising would be necessary. Here the discharge in the gas comes as a safeguard rendering the separation of contacts at the desirable condition, effecting the safe interruption of the circuit at the following zero point of the current cycle.

There have been attempts to interrupt the circuits by dispensing with the separating contacts as in the case of the brush on commutators where the area of contact between the brush and segment, beginning from a maximum, approaches zero continuously as the segment moves away from the brush. Here even as theoretical treatment shows, there is the necessity for a close synchronisation with the course of the current and in practice, it is imperfect. A discharge is operative in the last conduction of current. It is thus manifest that in the case of all successful dark commutation, the final step of the interruption of the current is performed by the glow effect, however feeble that may be.

The next problem, viz., that of prevention of the restarting of discharge after the current value has fallen to zero is accomplished by setting up conditions such that either the positive column or the cathode spot or glow cathode cannot re-form themselves. For high voltage switches it is the positive column that has to be suppressed. Various means are provided to compel the positive column to have such a small section at the stage when the current has fallen to the zero value that its temperature and degree of ionisation fall to too low values for its re-establishment. Here one has to take into consideration the thermal ionisation theory of positive column worked out by K. T. Compton. The solid barriers with restraining magnetic field in the 'de-ion-grid' circuit breakers, the motion of the cold oil under pressure in the 'oil blast' breakers and the motion of cold air in 'gas blast' breakers, in the 'expulsion' type fuses and in 'gas blast switches' are the developments introduced in the field of electrical engineering practice.

In mercury arc rectifiers, ignitron, thyratron, grid glow tubes and low pressure gas discharge tubes, the absence of a cathode spot and insufficient voltage to maintain a glow cathode are generally utilised to terminate the discharge upon reversal of polarity.

The low-gas pressure raises the voltage necessary to maintain the glow cathode, and so permits relatively high voltages to be handled. However, all these devices are subject to a type of failure. Occasionally and at random moments, in spite of the absence of conditions, which the present theory would regard as necessary, a cathode spot is formed at the moment of incorrect polarity and causes a short circuit in the device. The

statistical frequency of the occurrences of these 'back fires' or 'arc backs' is such as to indicate that possibly molecular aggregates are involved which may be impurities on the cathode surfaces or particles in Brownian movement through the gas coming in contact with the anode. It is also found that frequency of occurrences of these 'arc backs' increases rapidly when thirty or forty kilovolts are exceeded, so that the problem of this type of tube for very high voltages remains still unsolved. This phenomenon is of great technical importance, for on its successful solution rests the high voltage direct current power transmission which is the subject-matter of frequent discussions.

It is thus evident how 'the electrical conduction in gases' crops up at every point in an operating power system.

I shall next treat how the investigations about the nature of dielectrics is of extreme importance in maintaining the power systems. The problem of insulation plays an important rôle in the development of electrical power industry. Consequently, there has been a continuous flow of researches in the field of dielectrics:—gaseous, liquid and solid. Broadly speaking these researches are of two general types. The first is that of fundamental character and is carried out by applied physicists with a view to secure an insight into the mechanism which eventually may lead to an understanding of the useful properties of dielectrics and their behaviour when used as insulators. These properties are dielectric constant, electric conductivity, breakdown strength, dielectric loss and power-factor. The term 'dielectric behaviour' usually refers to the variation of these properties with frequency, temperature, voltage and composition. The second type of research is that in which efforts are made by engineers to develop directly improved materials and methods of insulation under the conditions of normal service by utilising any new discovery or suggestion made through researches of the first type.

I shall now present before you some of the recent fundamental researches in the field of dielectrics, particularly those which have a bearing on the application of dielectric properties to the problem of electrical insulation in power industry.

From the standpoint of insulation, the 'breakdown strength' of a dielectric is worthy of our first consideration. Persistent efforts particularly those using cathode ray oscillograph and other methods for following short time phenomenon have, however, resulted in a well-developed theory which has been universally accepted to explain the mechanism resulting in the electric breakdown of gases. The basis of this theory is the Townsend picture of ionisation by collision for which important modifications, due principally to the part played by the positive ion in the final spark over, have been necessary. Rogowsky and Wallraff have examined the question whether the breakdown over large gaps are due to local high stresses caused by

space charges or to ionic bombardment of the cathode They have concluded that the beginning of breakdown must be attributed to the ionising action of the positive ions. W. F. Bowls has reported that the secondary ionising mechanism necessary for the increased production of electrons requisite to spark over is not due to positive ions in the gas, but to the liberation of new electrons, by the bombardment of the positive ions in the gas on the cathode.

Theories of dielectric strength and breakdown of liquids take a wide range. The Schumann-Nikuradse theory of breakdown ties in the current voltage characteristic in much the same manner as now accepted for gases, and accounts the failure as an internal collision ionisation phenomenon. Kopplemann and Gemant invoke an electrode layer under high stress due to space charge acting on a layer of absorbed gas, thus creating gas pockets or filaments leading to gaseous ionisation and breakdown. Pure electric breakdown is apparently due to electric collision-ionisation and is recognised only in the purest liquids. Thermal breakdown on the other hand, due to the liberation of gases by heating, in impure liquids, is also evident in many cases.

The breakdown behaviour of commercial insulating oils is of special interest. It has been found that their electric strength increases with their degree of purity.

Large amount of important work has appeared concerning breakdown in solids. In this connection, the conclusion of S. Whitehead, supported by Von Hippel, is worthy of note. According to these authors, electric breakdown in solids is to be understood as an electron collision phenomenon originating through an excess number of electrons in the lattice. The frictional losses of these electrons are due to the oscillations which they excite by electrostatic influence in passing the ions of the lattice. This friction may be expressed as a function of the electron energy. Beyond the maximum value of this function, the frictional retarded motion of the electrons passes over into an accelerated movement down the potential gradient. Electric breakdown thus occurs primarily through the setting up of electron collision ionisation channels. The directional breakdown noted in crystals is a result of the shape of the excitation function, which is dependent upon the direction of the path with reference to the lattice and also upon the high gradients that result from the accumulations of space charge.

It has been found that the dielectric strength of solid insulators decreases markedly with increase of frequency.

Researches have been conducted by several physicists to study the process leading from initial ionisation to self-supporting spark or arc discharge. These studies are of special interest because of their obvious bearing on the mechanism of various protective equipments used in power industry.

Incidentally, it may be mentioned here that the dielectric losses in oils in the low-frequency range, are commonly due to ionic conduction. As the frequency is raised through the radio range, dipolar losses begin to appear. The variation of power-factor or of dielectric constant with frequency is not sharp. This want of sharpness has been attributed to the presence of several constituents having different values of ionic mobilities and dipolar properties.

The problem of 'stability' in oils has engaged the attention of physicists for some time. They have divided the oils into two groups. In one group are oils of the transformer type which are used for submersion and in which the important properties are continued fluidity and dielectric strength. In the other group are the oils used as impregnants, as found principally in capacitors and high-voltage cables. In the field of transformer oils, the action of oils on metals has been investigated. It has been found that copper gives the largest quantity of sludge. A relation has been established between the percentage of aromatic constituents in the oil, the frequency of the applied voltage and the amount of sludge formed. It is suggested that to prevent corrosion by insulating oil, copper should be protected by a layer of another metal, tin and lead being found useful for this purpose. It is stated that acid is not a determining factor in corrosion and water has no unfavourable influence on the dielectric loss of transformer oils. Stability in impregnating oils has been a problem for years. Instability is the word used to describe the slow deterioration of high-voltage impregnated paper cables. It has generally been assumed that the causes are to be sought in the impregnating oil. It has been found further that oils having a large ratio of dielectric constant to density show rapid deterioration under oxidation. Gaseous ionisation is known to be an important deteriorating agent probably through changes in the oil due to ionic bombardment. It is not always possible, however, to account for gas pockets or bubbles in well-impregnated insulation.

The impregnated paper power cable continues to receive intense study. The chief problems are the reduction in wall thickness through increased dielectric strength, permanence or stability as inherent in the properties of the basic materials and in the suppression of gaseous ionisation.

G. B. Shanklin has found that there is considerable improvement of power factor of impregnated paper, treated with carbon dioxide during drying and impregnating process. Though lead is not an insulating material, the lead sheath is a vital element in preserving the inherent properties of cable insulation. Improvements of lead sheathing technique are progressing. Especially noteworthy are the vacuum press (Atkinson and McKnight) for limiting oxidation and gas inclusions during

leading, the hydrogen press (Shankling) for similar purposes and other measures for greater uniformity of the resulting metal.

Physical structure and dielectric loss of impregnated paper, as related to the amount of contained air and under changes of voltage, temperature, frequency and pressure, are reported by P. Junius. The conclusions are, that the shape of the power-factor voltage curves at different temperatures changes very little in a dielectric containing large amounts of air. On the other hand, the shape of these curves varies noticeably in well-impregnated cable. In the latter case the change of power factor due to temperature change may be much steeper than that for a cable containing air. An increase of pressure by one atmosphere is sufficient to cause a flat loss-curve in a cable which contains much air.

The pressure principle has also received extensive trial. The advantages of pressure on the dielectric are increased dielectric strength and the suppression of internal gas voids. The problem is therefore to ascertain the most reliable method of applying the pressure either by an outside gas or liquid medium or by hydrostatic pressure inside the cable and also the proper ranges of pressures for securing best results. It has been found that oil-filled cable for the higher ranges of voltage is very suitable.

C. A. Grover discusses the feeding of oil to an oil-filled cable, with a detailed development of a method which permits a computation of pressure conditions resulting from temperature variations through the cable and at the feeding points due to load variations. The Callender Company has developed a single conductor impregnated gas-pressure cable with rating of 200 KV. conductor cross-section, 420 sq. mm.; thickness of insulation 23·6 mm. A small space is left between the impregnated paper insulation and the lead sheath. This space is filled after assembly with dry nitrogen at 14 atmospheres excess pressure, the lead sheath being heavily reinforced with copper tapes.

The causes of instability and deterioration continue to occupy our chief attention. In recent years we appear to have passed through a series of modifications in our ideas of the principal causes of cable deterioration. We have noted as chief suspect in successive periods, high inherent power-factor and loss, gaseous ionisation, wax-formation and oxidation. At the moment we appear to be leaving the oxidation period and reverting to that of gaseous ionisation through new methods for studying free gas spaces in the cable.

Careful studies are reported of the stress at which gaseous ionisation begins and as related to different grades of paper. It is stated that both nitrogen and carbon dioxide are the best gases.

Of outstanding interest during the past few years is the progress in the development of new insulating materials of both plastic and ceramic types. Especially noteworthy is the range of physical properties available in several new plastic materials.

Conspicuous among the new plastics are the various polymerised forms of monomeric styrol. Several investigations have been carried out on the applications of styrene. Of special interest is the control of the induction period of polymerisation and the rate at which the latter takes place. This has permitted the pre-impregnation of paper tape with the monomer with certain admixtures, preventing the sticking of the tape in rolls, polymerisation being effected after application, for example, in a cable joint. The possible use of styrene instead of oil as a saturant for high-voltage paper cable has been suggested.

Improvements have also been made in the composition of artificial rubber which is found to possess a number of advantages over natural rubber. The vulcanised synthetic rubber is replacing natural rubber in high-voltage rubber-insulated conductors, in water-proof insulated wiring and in many other cases. Thermoplastic synthetic rubber materials are replacing fibrous insulating materials in a number of services.

Numerous classes of synthetic resins have also been developed. Since November 1934 about one thousand new trade names for resin offered as insulation have appeared.

Many new ceramic materials have also appeared. New developments in ceramic for insulation are confirmed principally to those for radio service. All these materials have been introduced as insulators to meet the demand for low dielectric losses in the high-frequency range.

I shall now relate to you just a few items of interest in the field of communication. The rapid expansion of Wire and Radio Communication Systems after the close of the World War in 1918 has necessitated the development of various communication industries utilising the results of fundamental researches. Limitation of space does not permit me to deal with more than a few of the researches which have been of wide application. In transmission of telegraph signals over circuit, the speed of signalling in bands or words per minute varies inversely as the product of total capacitance and total resistance of the circuit. The long cable circuit, specially of submarine type, has large capacitance and large resistance and thereby the speed of signalling is reduced to 50 to 60 words per minute. The effect of this inherent capacitance could be overcome by increasing the circuit inductance, that is, by 'loading' the circuit.

The case of transmission in message and broadcast programme telephony is more complicated since it involves a large frequency band (i.e. 100–4,000 c.p.s. for message and 31–10,000 for broadcast programmes. It follows from theoretical consi-

derations that the product of circuit capacitance and resistance (C . R) must be equal to the product of circuit inductance and leakance (L . G) in order to have the transmission loss and the velocity of propagation same at all frequencies in the band thereby eliminating the frequency and phase distortions. In trunk cable circuits this can be roughly realised in practice by inductance (L) either by insertion of loading coils wound over magnetic material cores at intervals or by wrapping magnetic material tapes helically over the conductors.

The requirements of a loading coil are (1) the permeability should be high and remain constant for all frequencies; (2) eddy current and hysteresis losses should be negligible for all frequencies in the band; (3) leakage or superimposed D.C. should not alter the working point on the magnetisation curve appreciably; (4) the ratio of resistance to inductance of the coil should be very small for all frequencies: and (5) coil size should be as small as possible. For the continuous loading, the magnetic material tape should be very thin about 1/10 of a mm. and at the same time the increase of inductance should be adequate for the purposes, thus requiring a material which has a high permeability for currents of the order circulating in telephone circuits. At the same time the requirements (2), (3) and (4) mentioned above for loading coils must also be satisfied.

Electrolytically deposited iron in the form of dust has served as core material of the loading coils till recent years, while 78·5-permalloy tape has replaced iron tape for continuous loading since about two decades. There has been still sufficient room for improvement in both. The audio transformer used in radio equipment or connected between transmission line and programme repeater requires its response characteristic to be strictly uniform from 30 to 10,000 c.p.s. or even more. For cores and pole pieces in loudspeakers it is necessary to have high permeability in the range of flux densities between 10,000 and 20,000 gausses. Use of iron dust in audio transformer and of stalloy in loudspeaker fails to give the desired performance.

The study of the magnetic properties of certain alloys of iron, nickel and cobalt has revolutionised the design of loading arrangement in telegraph and telephone transmission systems, of audio transformers and retardation coils in communication equipments and of cores and pole-pieces in loudspeakers

The properties of these alloys were discovered through exhaustive researches in which all possible combination of three metals—iron, nickel and cobalt—were explored. The factors which contribute to the properties of the alloy the purity of the elements used in the alloy, their preparation and the heat treatment.

The permalloy series includes nickel-iron alloys containing 30 to 95% of nickel. Remarkable variations in magnetic

properties with composition are revealed in this series of alloys. The initial and maximum permeabilities of 45-permalloy under standard practice of heat-treatment are 2,700 and 23,000 respectively. For cores requiring high permeability for flux densities between 10,000 and 15,000 gausses, this alloy is specially useful. The design of cores and pole-pieces for loud-speakers may be done with advantage with this alloy. In 78·5-permalloy, quenching gives a higher maximum permeability than in any other permalloy and initial and maximum permeabilities of 10,000 and 105,000 respectively are developed. The hysteresis loss and the coercive force of quenched 78·5-permalloy are minimum. This alloy is suitable for continuous loading of telegraph and telephone cables. The negligible magnetic losses, non-alteration of magnetic properties with D.C., higher core permeability and material decrease in the size of loading coils have led to the use of improved 80-permalloy dust core in them. For audio transformers, both 3·8–78·5-permalloy and 3·8–80-Mo-permalloy have been used and uniform response from 30 to 16,000 c.p.s. have been obtained.

Perminvars are alloys of nickel, iron and cobalt. The constancy of permeability and extremely low hysteresis loss makes 45·25-perminvar the right material for applications where distortion and energy loss are detrimental to high grade transmission. Since the discovery of the properties of perminvars, they have been used for chokes, audio and carrier frequency transformers, filter elements, etc., in equipments designed for high grade transmission. It is specially suitable for continuous loading of long submarine cable circuits for voice-frequency or carrier frequency operation.

Permendurs are alloys of iron and cobalt. The principal magnetic property of these alloys is high permeability in the range of flux densities between 10,000 and 25,000 gausses. Permendurs have been applied with success to the design of cores and pole-pieces in loudspeakers and certain special types of telephone receiver where their principal magnetic property has been utilised to the best advantage.

One of the most recent advancements in communication art has been the wide band transmission on circuit between two stations to give as many as 240 or 320 high grade telephone channels simultaneously by employing the frequency range ·06–1·024 Mc./s. or 0·5–2·1 Mc./s. depending upon the number of channels. Such multi-channel carrier systems are worked on coaxial cables on four-wire principle. If one and the same coaxial cable is used, two coaxial circuits are provided therein, one of them for transmission of bands in one direction and another for transmsision of bands in the reverse direction. If two separate coaxial cables are used for two directions, then each cable consists of one coaxial circuit only.

The coaxial cable circuit is much more suitable medium than open-wire and ordinary cable circuits for transmission of higher frequencies as mentioned above. Among the various advantages like ease in construction and maintenance, lower cross-talk level, etc., may be mentioned the lower transmission loss of pronounced stability. Loss in a transmission circuit is made up of (*a*) conductor loss, (*b*) insulator loss, and (*c*) radiation loss. In coaxial cable circuit, the radiation loss is negligible since the unearthed central conductor is entirely surrounded by earthed concentric conductor and insulator loss is considerably less and further much more stable. The other factors remaining constant, the reduction and stability of loss depend entirely upon the type of insulator used.

When the system was first launched into the field, the coaxial cable had its central copper conductor supported at intervals of ¾ inch by hard rubber discs. In recent years, improvement in reduction of insulator loss and obtaining higher stability has been realised by use of polystyrol compounded with rubber or balata under trade name of 'Superstyrex'. Earliest reference to the electrical characteristics of the solid polystyrol is contained in a patent by Matthews in 1913 where the inventor proposes to replace hard rubber, celluloid, vulcanite, ebonite, glass, wood by polystyrol or polystyrol compounded with rubber. The International Telephone and Telegraph Laboratories, Ltd., subsequently took up the studies of polystyrol with particular regard to its application to the insulation of cables. From this study a number of patents evolved dating from 1929 down to the present day dealing first with combinations of polystyrol with rubber, balata, etc., of a thermoplastic nature suitable for extrusion but later with other processes and applications.

The permittivity of polystyrol is low (2·2 to 2·6), and its insulation resistance under A.C. or D.C. voltages is very high even at high temperatures or under high humidity. The material retains its high grade insulating properties even after immersion in water and this fact has led to its use as submarine cable insulator replacing guttapercha. The inclusion of chemical impurities in the material during manufacture appreciably affects the conductance of the material to the extent that power-factor varies from ·0001 to ·0006. While dielectric losses of this order may, from some points of view, be neglected, there are other electrical insulation problems of the type involved here in which the increment of even small dielectric losses are of importance.

Commercial utilisation till recent years has been hampered by the absence of supplies of monostyrol, the basic material, on a commercial scale. This is now available from chemical plants in several countries.

In addition to the application in coaxial cable referred to above, widespread application of the material to condensers, moulded castings, etc., has already begun. Lacquers have been developed and there is a tendency to use polystyrol for all cases where the highest grade of insulation is in demand.

The outstanding problem is that of employing a hard, glass-like material in situations where toughness, flexibility, etc., are required. This necessitates engineering work of a high order, firstly, to design the form of insulation of the cable, apparatus or machine in such a way that a variety of 'Superstyrex' may be manufactured to suit; secondly, to design a suitable variety of 'Superstyrex'. In the latter problem, little or no reliance can be placed on plasticisers. In general, plasticisers are considered as impurities particularly in applications involving H.F. alternating fields.

I would now turn to the most important branch of communication industries, namely, thermionic vacuum tube industry and consider some of the problems associated with the design and manufacture of modern receiving tubes. During the last fifteen years, the efforts of tube manufactures all over the world have been concentrated to increasing the performance of receiving tubes by evolving several new types for special purposes and by improving existing types by modifications in the mechanical design, improvement in electrodes and cathodes, better arrangement of insulating and spacing the electrodes and exhaustive studies on 'gas properties' of electrode materials and on 'getter' materials Some new contrivances like 'grid-winding machine' have to be invented. A study of the causes and methods of reducing 'noise' has also received due attention. Developments in radio receiver design are continually demanding new types of tube and modifications to existing ones. The manufacturing plant must therefore be sufficiently flexible to allow changes to be made rapidly.

A close control has to be made of the mechanical properties of materials used for components. The manufacturer is limited in his choice of metals for electrodes to only those which have high melting-points and low vapour pressures even at temperatures as high as 1000–1100° C, the temperature reached by the electrodes during pumping operation. Nickel is invariably employed as the plate material and for electrode support wires. It is not sufficiently rigid for the winding wires of grids for which alloys containing molybdenum or nickel-manganese alloys are used. Iron is sometimes used as plate material for screen-grid tubes in which the anode is in the form of two plates.

The manufacture of 'grids', which a few years ago, was an extremely laborious process, is now carried out on special machines called 'Grid-winding machines' capable of winding as many as 200 to 1,000 grids per hour. The grids are wound

in lengths of about 60 cm. and subsequently cut into the required lengths. By operation of a cam on the machine, gap or gaps can be introduced in the winding of grids which are necessary for a variable-μ characteristic. It will be realised that uniform mechanical properties of the wire for winding grids (which are of course always slightly larger than the mandrels on which they are finally pressed or stretched) are very essential. Also the strain introduced during final shaping must be small, otherwise distortion will occur on heating.

Equally important are the 'gas properties' of the electrode materials. The term 'gas properties' includes not only the amount of gas which may be included in the metal but also the capacity of the metal to re-adsorb gas on its surface. This last factor is in some cases much more important than the first. Investigations of the sources of gas in receiving tubes have revealed that carbon dioxide adsorbed by the electrodes during decomposition of the barium-strontium carbonates on the cathode is much more difficult to remove than the residual gas existing in the metal. The nature of the surface of the electrodes has an enormous effect on this adsorption.

For insulating and spacing the electrodes from one another, mica is generally employed. It is decidedly superior to other possible materials as it is mechanically strong even in very thin sheets, can be formed into flat plates of any desired shape with great accuracy and has just sufficient flexibility to allow the electrode support wires to slide easily through holes without becoming jammed. For temperatures up to 500°C, the best quality ruby clear mica has good insulating properties, is chemically stable and evolves little gas. Above this temperature, mica rapidly decomposes with the liberation of water vapour, one of the most harmful gases in a tube and electrolyses. In tubes where still higher temperatures are reached, alumina, magnesia or steatite, pressed from powdered material to the required shape and sintered at 1500°–1800°C, are employed.

One of the most important features of the modern receiving tube is its highly efficient oxide-coated cathode. The various types of emitters that have at various times been used may be classed as follows:—(*a*) Clean-metal emitters; (*b*) contaminated-metal emitters, and (*c*) oxide emitters. In early days, the desirable features in an emitter were only thermionic emission, mechanical strength and long life. Emission efficiency was not considered a serious problem. All the early tubes were of directly heated filament type. Tungsten suited their requirements very well indeed and may be cited as an instance of clean-metal emitters. Later on, in order to improve the mechanical properties of the tungsten, thorium oxide was added to the tungsten oxide during the manufacture of the tungsten, about 0·7% thoria being obtained in the final wire. Langmuir showed that thoriated tungsten had a considerably higher

thermionic emission than tungsten at the same temperature. Thorium obtained by reduction of the thorium oxide diffuses into the surface of the tungsten and at temperatures where bulk thorium could not exist, a mono-atomic layer adheres to the tungsten surface with the result that its work function is reduced. Thorium-on-tungsten is an instance of next class. The discovery that the work function of a metal was reduced when a layer of atoms of another electro-positive metal was present on its surface led to much work on caesium-oxygen-on-tungsten emitter. The more electro-positive the contaminating metal is, the more the work function is reduced. A still greater reduction in work function is obtained when the contaminating film consists first of a layer of electro-negative atoms such as oxygen and then a layer of electro-positive atoms. The most efficient form of such type of surface yet developed is caesium-on-oxygen-on-tungsten which is another instance of contaminated-metal emitter. The demand for highly efficient cathodes which were inexpensive to operate directed the attention of the manufacturers on the oxide emitters. As the emitter becomes more efficient, the degree of vacuum becomes increasingly important because of the 'poisoning' effect of gas on the emitter. Hence a great deal of improvement in the high-vacuum technique had to be achieved. The oxide cathodes are generally produced in the evacuated bulb, and a large quantity of gas has to be removed from the valve before any activation of the cathodes can be attempted.

In indirectly heated types, the cathode is generally a hollow tube of circular, oval or rectangular section which is heated by a filament inside the cathode and insulated from it. The core material is generally tungsten. Since the heater wire normally works at several hundred degrees above that of the cathode surface, it is essential for the wire to have a high melting-point. Another form of core now being used consists of molybdenum-tungsten alloy which has many advantages, since it retains the ductility associated with the molybdenum and yet has a melting-point well above that of molybdenum and a vapour pressure which is negligible below 1750° C. The insulating material consists of a refractory such as alumina which is sprayed on the heater. Magnesia has also been tried as an insulating coating but has been found unsatisfactory for several reasons.

A 'getter' is used for maintaining the vacuum in a tube after it has been sealed off. The alkaline earths, the alkali metals and magnesium are common getters. An alloy of barium and magnesium and barium are mostly used at the present moment.

If the metal of which the getter is composed is relatively stable in air, it is welded to a metal disc and dispersed by 'high frequency heating' of the disc. If the metal is an unstable one like barium, it is packed inside a closed container before welding.

The high vapour pressure generated on heating is sufficient to burst open the container and the metal is dispersed. For avoiding any deposits over the electrode bonding system, the getter dispersal is usually directed towards the bulb wall by suitable design of container. When very high inter-electrode insulations are desirable for special tubes, alkaline-earth oxide getter is preferred This is sprayed on to a metal disc in the form of cathode coating and decomposed by high-frequency heating of the oxides. The oxides act as getters when cold. It will be noted that since the emitting cathode itself is a mixture of alkaline-earth oxides, it will also adsorb gas in the active state.

Refrigeration Industry.

I shall next take up 'Refrigeration Industry'. Refrigeration was born in the laboratory. It remained for a long time confined within the laboratory to be used in various physical investigations. The mechanism and the laws governing it, have been the subject of studies for physicists for more than a century. Even at present the production of low temperatures and the study of the properties of materials under extreme low temperature conditions form the subject of research in special Cryogenic laboratories.

The first industrial application was the production of ice. The first commercial refrigerant was the ammonia gas which on compression liquefies and the quick evaporation of the liquid results in reduction of temperature, so that heat is abstracted from the container sufficient to freeze the water in it. Physical investigations disclosed a number of other substances such as sulphur dioxide, ethyl chloride, etc., which could be used as refrigerants. One now finds their industrial use all over the world.

It is, however, well known that the above-mentioned mechanism was not capable of being utilised for obtaining sufficiently low temperatures. The search for new principles and new methods were being vigorously pursued and this has led to the means of securing extremely low temperatures. I would like to bring before you, though they are well known, some of the basic ideas underlying these processes whose proper understanding has contributed to the immense growth of the industry. Let us start from well-known properties of gas, namely, that if a gas is allowed to expand freely at high pressures, the molecules would separate and some work has to be done. It is the kinetic energy of the molecules which supplies the energy and accordingly one finds the lowering of temperature. This is evidently converted into potential energy represented by a change in the electro-magnetic stress in the molecules. The molecules are not only in constant motion but are in continual collision with one another and these collisions also result in electromagnetic stresses being set up. If it could be imagined that at a particular

instant of time all the molecules in a state of collision are stationary, one would certainly get the maximum electromagnetic stress and for that moment whole of the kinetic energy would be reduced to zero. The gas would be at the absolute zero of temperature. At the next instant a repulsion would be set up among the molecules and this would lead to a rise in the kinetic energy. Such exceptional conditions do not arise in practice and one finds an average condition. But this leads to an understanding of the fact that under certain conditions, a gas even on expansion has a tendency to get heated. So there are two effects in every gas—one leading to cooling depending on the degree of separation of molecules and another to heating depending on collisions and this would increase with temperature. One thus expects in all gases at a sufficiently high temperature the net effect of expansion to be a rise in temperature. At a certain temperature, namely, the inversion temperature, there is no change and below it a lowering in temperature on expansion. The full realisation of this phenomenon leads to the proper application of the mechanism to secure low temperature.

Let us take the case of air for which the Joule-Thomson effect is by no means small. Thus at 0° C air is cooled 0·29 degree centigrade for a fall of pressure of one atmosphere. for a fall in pressure of 200 atmospheres the cooling effect is about 40° C. Roughly speaking if the molecules are about two diameters apart and are then separated so as to be ten diameters apart, they lose about 15% of their kinetic energy. It would appear therefore that to liquefy air which has a boiling point of about 194° C or 79° K, a fall in pressure of 1,000 atmospheres would be required. However, in practice, expansion to atmosphere pressure is rare, for while the cooling produced depends on the fall in pressure, the work done in compressing a gas is proportional approximately to the logarithm of the ratio of air pressures. Again, liquefaction at ordinary temperature is impossible, for the air must be below the so-called critical point, which for air is 132° K. This therefore means that some arrangement would be required for a preliminary lowering of temperature. This device, known as 'Cold regenerator' or 'Heat exchange', was developed soon after the discovery of Joule-Thomson Effect. In general this consists of two series of closed tubes, through one of which the compressed gas proceeds on its way to the expansion nozzle, and through another, in close thermal contact with the first, the relatively cold expanded gas returns. In fact the realisation of the Joule-Thomson Effect under proper conditions led Linde and Hampson to design and build machines for liquefaction of air for industrial purposes.

There is yet another aspect of the same phenomenon. A compressed gas would get cooled when by expansion in an engine, it does external work. The bombardment of the rapidly moving molecules of gas on the piston constitutes the pressure

and as the piston moves and does work, some of the kinetic energy of the molecules is transformed into external work. The gas on expansion would have lower temperature. The gas to be liquefied is compressed and cooled by water or air. Part of it then passes into an engine, does work by expansion and is thereby cooled. It then passes into a condenser to act as heat exchange mechanism to cool another part of the gas from the compressor below its critical temperature. To liquefy air, the compressed gas in the engine should be at a very low temperature at about 120° C. This process has been commercially developed by Claude. It is rather interesting to note that Kapitza adopted this method for the liquefaction of helium. The mechanism was capable of reaching below 10° K.

It would not be out of place here to present before you how other properties of material are being utilised for obtaining extremely low temperatures. By the expansion of a compressed gas with or without external work being done, coupled with the cooling due to evaporation of the resulting liquid it has been possible to obtain temperature less than 1° K. While it is most improbable that the absolute zero of temperature can ever be reached, advantage has been taken of the magnetic properties of matter to approach it very closely. In general the magnetic dipoles get arranged in orderly fashion at comparatively, high temperatures but there are a few substances, such as iron-aluminium alum, in which random orientations exist at very low temperatures. When these substances are at the lowest temperature attainable by the methods previously described and a magnetic field is created, the field controls the dipole direction and heat is developed. This heat is slowly absorbed by the surrounding substances and when the low temperature is restored, the magnetic field is removed. The dipoles get back to some extent into the disordered condition again and consequently the temperature is lowered. In this way a temperature as low as 0·003° K has been attained.

The need for the refrigeration as a direct agent has largely been utilised for the purpose of cold storage, where rooms are cooled with the help of a bank of coils through which brine is circulated. The brine is usually cooled previous to its circulation by means of suitable refrigerating chamber. Cold storage has been developed within the last few years to such magnitudes that one could find now the refrigerated space in ships bringing food to Great Britain alone amounting to not less than hundred million cubic feet. Today there are single ships having refrigerated space of over half a million cu.ft. capacity and capable of carrying cargoes amounting to 5,000 tons. The capacity of the public stores in Great Britain alone in 1937 amounts to 50,000,000 cu.ft. The annual output of artificial ice is of the order of one and a half million tons and the fishing industry of Great Britain uses more than 700,000 tons of ice annually.

Besides the ordinary ice, one finds now the industry of solid carbon dioxide coming to the forefront. It is rather wonderful that a product, which was used only in the physical laboratories in 1926, has become in bare fourteen years' time an important commodity. There are at present in America more than sixty plants for the production of solid carbon dioxide and in other parts of the world, namely, in England, Germany, France, Australia, Japan, South America, Africa, India and Canada, the number of such plants is more than eighty. The properties of solid carbon dioxide are sufficiently unusual to suggest a host of applications. It sublimes directly from the solid to the gaseous state at pressures below 5·11 atmosphere. At one atmosphere the temperature of sublimation is −78·5° C. At 5·11 atmosphere pressure the triple point occurs at −56·6° C. The liquid cannot exist at temperatures below that of the triple point nor at pressures below 5·11 atmosphere. Further its critical point is at 31° C at 75·79 atmosphere pressure so that the gas can never be liquefied above 31° C, i.e. above the critical temperature and at high pressure, gas and solid are in equilibrium. It has no true melting point and the latent heat of sublimation at the ordinary atmospheric pressure at a temperature −78·5° C amounts to 136·9 calories per grm. Its high specific gravity coupled with its high latent heat materially reduces the space required for storing a given amount of cooling effect. At present it finds the largest applications in the food industries especially the ice-cream industries of the United States. It has found wide application as preservative for meat and fishes as well as eggs. Only point against it is that it is still ten times dearer than ordinary ice even in large commercial productions.

The cold storage industry has utilised a number of other devices such as humidity recorders, temperature recorders, pressure recorders, ozonisers, all of them products of investigation of applied physicists.

I shall now bring before you the question of air-conditioning and air-hygiene, getting into prominence by the introduction of refrigeration in its various aspects. At first it was limited only to big establishments such as public halls, auditoriums, cinema houses, and air-conditioned trains. But now its size is reduced to that of a household appliance and single room conditioners are at present marketable commodities.

I shall now relate to you some of the indirect applications of this industry. When the demands for the liberal supply of oxygen for medical and industrial purposes first arose, they were met by chemical processes, namely, the oxidation and deoxidation of barium oxide. But soon after the introduction of the air liquefaction processes of Linde and Hampson, oxygen and nitrogen are separated by processes of rectification from liquid air. In 1938 thousand million cu.ft. of oxygen has been consumed

in the welding industry. Today single plants are in operation which produce as much as 80 tons of nitrogen per day to be used in the manufacture of cynamide, the nitrogeneous fertiliser formed by passing nitrogen gas over heated calcium carbide. For the manufacture of synthetic ammonia considerable quantity of nitrogen is being daily utilised. In 1894 Rayleigh and Ramsay discovered argon as a constituent of our atmosphere and now the lamp industry alone consumes ten million cu.ft. of argon extracted from air every year and at present one thousand million lamps filled with argon are manufactured by the different lamp industries of the world. The annual saving in the light bills of the world exceed many million pounds. Neon is also another constituent of the atmosphere which is extracted from liquid air. Its use in the vapour discharge lamp for advertising purposes and for beacon lights is increasing every year. These results could not have been obtained without the refrigerating machineries whose principles and mode of operations have entirely been developed by the physicists, pure and applied.

Automobile Industry.

As an example of application of applied physics to industry I shall next choose 'Automobile Industry'. This is less than half-a-century old and it could not have been earlier. Let us now consider how different branches of applied physics have contributed to the development of this industry.

Firstly, one finds 'Properties of Materials' ranging from the cast iron to the varied types of alloy-steel, aluminium and its alloy, required to form the different members of the engine and its power transmitting mechanism. Steel is required having properties to stand high stresses under high temperature conditions. Here not only high tensile strength but also high torsional rigidity and hardness to resist friction and wear under extreme conditions are necessary. One has also to know how far one could exceed the elastic limits of its running parts to provide against accidents. One should also acquaint himself with the effects of heat treatment of these different classes of materials to impart to them the required properties to serve the needs of the machine. The determination of hardness characteristic is performed by the application of Hertz's theory of impact in the different testing machines evolved for the purpose. In its body building, one must know how far one should exceed the elastic limits under different conditions and to attain the desired plastic deformations. The general knowledge of kinetics is essential for the proper assemblage of its members and their linking, so that one could secure the desired motion and speed under different conditions. One should not disregard the lubricants. The theoretical interpretation of the action of lubricants awaited the work of Osborne Reynolds in 1886, in

which he considered the lubricating film to be moving between two parallel plane surfaces. Applying the relations of classical hydrodynamics, he deduced the equation underlying the theory of 'thick film lubrication'. The specific case of the journal bearing was first satisfactorily treated by Sommerfeld with the assumptions of liquid incompressibility, absence of turbulence and independence of viscosity on pressure and rate of shear. He considered the minimum film thickness for a given clearance and showed that it increases monotonically with increasing liquid viscosity, journal speed and decreasing load. The journal would rise and shift from an effective solid contact with the bearing until it becomes practically concentric with the bearing as the speed is increased or the load is lessened. The temperature variation of viscosity, however, could not be satisfactorily dealt with as it decreases with increasing temperature and it was Andrade who suggested an exponential formula connecting the relation. The last conference on lubrication held at The Hague pointed out the various factors relating to the liquid lubricants mainly from the theoretical standpoint and it was found that in the present state of our knowledge it is difficult to apply any set formulae. The oil in the crank case of an engine under heavy duty will reach 140° C, the bearing surfaces 150° to 200° C and at the upper piston ring grooves and underside of the piston crown temperatures may exceed 250° C. The trend of automobile industry towards lower weight of engine per horse power and higher engine speed increases the difficulty of suitable lubricating oils. So the lubrication specialist is making a continued effort to understand the mechanism of the oil itself under such trying conditions. The susceptibility of the different oils to oxidation and the use of different types of inhibitors to counteract their effect has made some success. The question of film rupture is another factor concerning the contraction of the film, once it has been pierced by projections. To counteract it, one has to requisition another property, namely, that of adhesion of the lubricant to the metallic surfaces. This property is not very well understood and is designated by 'oiliness' of the liquid lubricant. The broad field of lubrication demands the attention of applied physicist in the application of the basic work on the theory of liquid state and surface phenomenon.

It is not strange, therefore, that large organisations such as Gulf Research and Development Company, and Standard Vacuum Oil Company have started organisations with applied physicists at their helm, to work out this intricate question of proper lubrication.

Secondly, the thermodynamical aspect of the conversion of heat into motive power comes into prominence here. Here one finds, different types of fuels injected into the combustion chamber, suitably ignited, finally ejected out of it into the

atmosphere. To any one, who is acquainted with the progress of this industry, it is well known how the variety of fuels so far utilised required considerable investigations to lead up to the present stage, how economic considerations are showing the need for more easily obtainable fuels.

Recent investigations regarding the design and performances of high speed engines indicate that the lines of enquiry could be fairly grouped under the following heads.

The design of the combustion chamber with its inlet and outlet valves and their proper timing mechanisms; the determination of the behaviour of the fuels during combustion; the mechanism of the expulsion of the products of combustion as noiselessly as possible.

Quite an amount of valuable work has been done regarding the proper design of the combustion chamber. The extent of our knowledge, however, about the actual process of combustion in its different stages, the intermediary products formed and the final constitution of the expelled gases are yet matters of some uncertainty. But this is of extreme importance. The thermodynamic treatment of the petrol engine does not adequately handle that portion of the cycle where combustion occurs. It takes cognisance only of the states of the system immediately before and immediately after combustion. In other words, thermodynamics pay little or no attention at present to the rate of chemical transformation during an engine explosion for want of suitable data, even though this factor determines to a large degree the rate of pressure development as well as the maximum pressure attained. Thus in the thermodynamic treatment of the engine cycle, it is frequently assumed that combustion occurs instantaneously, releasing all the energy of combustion when the piston is at the top dead centre. This is not in conformity with the actual state of affairs.

One has, therefore, to ascertain the nature of the different gases formed in the combustion chamber in the successive stages of ignition and explosion to form an accurate idea of the power developed in the process. In fact, for the study of the new cycle of an internal combustion engine or for the comparison of the different processes, such as, the influence of different heat losses, different combustion lines and different scavenging effects, the entropy diagram is of the greatest help. This has been pointed out in a recent lecture delivered by Prof. Eichelberg before the Institution of Civil Engineers, London. It is well known that the entropy of a gas can be expressed by its temperature and volume as well as by its specific heat. Now specific heat at constant volume, C_v, is du/dt and therefore one must have the energy u theoretically given as the kinetic energy of the molecules. The kinetic theory of gases shows that the rotational movement of the molecules is given by the degree of freedom and is proportional to the absolute temperature. The

quantum theory adds the energy of oscillation which is given by Einstein formula when the frequency of the atoms has been measured by spectroscopy or by Raman Effect. In deriving the entropy diagram, therefore, a knowledge of the gases developed by combustion is of some importance. Taking purely the chemical view of the problem, one should expect carbon dioxide, nitrogen and water vapour to be the gases formed under ideal conditions; but in actual practice such ideal conditions are rarely obtained, as everybody walking about the streets feels it, when he is encountered with acrid fumes emitted from the exhaust of a passing automobile. Further, any chemical method of sample analysis of the products in the various stages is beset with two main difficulties, namely, the inaccessibility of the flame and its products and the extreme rapidity of the reactions.

It will be my purpose now to show how an applied physicist has come to help the automotive engineer. Quite recently a series of systematic investigations has been conducted in the research laboratory of General Motors Company of America by Rassweiller and Withrow where purely physical methods have been adopted for the purpose. It is clear that the whole phenomenon takes place within the explosion chamber which admits fires and expells the charge thus offering facilities for the observation of the whole process in progressive stages. One has to take successive pictures of the flame production as it progresses and for this reason an experimental cylinder was designed, provided with a suitable glass top which would resist the temperature and pressure prevailing in the chamber. A suitable device has to be provided for a cinematographic film camera which could take rapid successive pictures. For this reason the camera lens has been divided into two parts. The fore-part being a stationary one which performs the first stage of the image formation of the flames and the second part consists of a number of similar lenses arranged along the periphery of a disc moving behind the fore-lens. The film in its carrier is so disposed, that whenever any of the moving lenses align with the fore-lens, an image of the flame is formed on it and this movement of the disc can be maintained in synchronism with the motion of the piston of the combustion chamber. In fact this becomes a cinematography of a rapidly moving phenomenon. The speed at which one has to operate this mechanism for an engine of 900 r.p.m. extends from 2,000 to 10,000 pictures per second. The flame pictures show that there are two regions of maximum luminosity, one in a region around the spark plug and another along the forward edge of the flame and they are of distinctly different nature.

To study the nature of these flames, the method of spectroscopy has been requisitioned and here a spectrograph is mounted in the place of the film. In fact the slit occupies the place of the film and the film, as it were, is displaced back to take the

instantaneous emission spectrum of the flame. With such an arrangement the spectrographic record shows very interesting details and is compared with the spectrum of the inner cone of a petrol torch operating in air. For the region of the flame front, one finds the familiar CH and C_2 Swan bands. The emission spectrum close to the sparking plug gives no trace of the above-mentioned two band systems. It consists of a very diffuse band system extending from 3800Å to 8500Å. They have been observed in the flame of CO and O_2 by Weston and Kondratjew and are attributed by them to carbon dioxide. In the ultra-violet region of the spectrum emitted from the flame front and after-glows, one finds OH bands. In addition to the OH bands, a group of very diffuse bands extending from 2800Å to 3700Å has been observed in flame front but not in the other region. On a careful examination of the literature on band spectra, it is found that Emeleus observed the spectra in the flame of burning ether. Quite recently Vaidya while studying the spectra of the inner cones of ethylene flames observed these two groups and attributed them to the triatomic molecule, HCO. They are entirely absent, however, in the region near about the spark plug. It may be deduced that petrol is not directly burning as a flame in the close proximity of the spark plug.

The sequence of reaction occurring in Bunsen burner flames has been carefully studied long ago (as early as 1892) by Smithels and Ingle and they found only carbon monoxide, hydrogen, carbon dioxide, water and nitrogen above the inner cone of the Bunsen burner flame. No hydro-carbons were present there. One has therefore to consider the mechanism a little more closely. Here one can state that the energy of combustion is liberated first in the flame front due to the reaction of petrol and air. Any small portion of the charge, which at the time of ignition is located near the centre of the combustion chamber, is evidently compressed by the approach of the flame and forced away from it. When the flame front reaches this portion of the charge, the sudden release of the energy of combustion quickly raises its temperature and this portion of the charge expands. As the flame moves on through the charge, the burnt gas is again compressed and it is forced back towards the spark plug so that the combustion really takes place in two stages. In calculating, therefore, the total energy of the system, one has to take into account all these considerations in the calculation of the entropy of the system.

The understanding of this process and the information secured from spectroscopic observations have recently been utilised in the design of some of the modern types of high speed engines and it has been found that their performances are in fairly close agreement with those derived from theoretical calculations.

In the study of fuel injection in the working chamber, one has to consider the action of carburetters, which by proper mixture of air and liquid fuel, produces the spray. Though Rayleigh first investigated the formation of sprays from liquid jets, it was Castleman who applied Rayleigh's theory specifically to the atomisation of liquids in an air stream under conditions similar to those occurring in carburetters. Scheubel determined the drop sizes of the sprays of alcohol—water and alcohol—petrol mixture from a carburetter jet by using spark photography and on the basis of these observations suggested a relation between air pressure, jet diameter, density of the fluid and its viscosity. The disrupted sprays were experimentally investigated by Kuehn, de Juhasz, Zahn and Schweitzer and others. From their work it is suggested that the atomisation of liquid jets may be due to the turbulence of the liquid and a critical velocity is required to produce the turbulence.

There has been a large number of theoretical and experimental investigations to understand the proper mechanism of jet formation in different types of fuels and still there are factors awaiting solution.

Now, about the exhaust. One gets some idea of the complicated motions in the exhaust of an engine by a close observation of the swirling motion of smoke issuing from a chimney or the more complicated motion of steam issuing from the funnel of a locomotive or still more complicated motion of the smoke cloud issuing from a big gun after firing of the projectile. The usual formula is based upon the assumption of steady state in the chamber, so that the distribution of energy in the chamber may be ignored and the kinetic energy of the issuing jet equated to the work done in maintaining constant pressure in the chamber. Exhaust of an engine is a transient phenomenon. Hence a great deal of justification is required in applying to it a formula, relating to a steady state, in which it is assumed that the energy in any particular unit of the gas, remains in the same unit throughout its passage through the chamber and the exit pipe and that no unit gains energy from or loses it to neighbouring units. The present state of the theory is in a rather unsatisfactory state. Quite recently a number of experimental studies are being conducted to secure materials for the proper development of the theoretical aspect.

Aeronautical Industry.

Air transportation is the youngest of any of the industries so far discussed. In its commercial aspect it is truly an 'infant industry'. Not only the designers but also the executives are on the average very considerably younger than the men occupying analogous positions in most other industrial fields. The industry has grown up with an unusual absence of tradition

and experience. This is indicative of the fact that all the developments have been based, to a remarkable extent, on the results of research and theoretical calculations. An important feature of aeronautics lies in the extreme narrowness of the margin between success and failure and in the terribly serious consequences which may result in failure. This has placed a tremendous premium on exactitude and has greatly stimulated activity in research of all kinds. All the problems of aeronautics are essentially physical in nature and it is therefore not strange that it has furnished an unusual field for the intensive use of applied physics. I shall merely mention a few of the various branches of applied physics which have been applied to aeronautical problems and then shall discuss in a little more detail the most fundamental aspect of them.

For any fuel burning power plants, thermodynamics plays an essential part. The difficult problems of heat conduction have to be solved in aeronautics, because aircraft engines demand high pressures for large power output, consistent with low weight and economic fuel consumption. One has to be acquainted with the physics of the air to reckon the meteorological factors on which are based the different problems of flight. Without this aid. air transport would be almost impossible, since weather troubles would make air services so unreliable as to eliminate most of its economic usefulness. Electricity and magnetism have largely been used in connection with aircraft instruments and radio, two of the elements of vital importance for satisfactory air travel. For noise reduction acoustics have recently been requisitioned. Mechanics in the field of aeronautics is of basic importance. It is well known that many of the basic laws of mechanics were discovered as a result of problems which arose in the attempt to serve specific engineering needs. The classical laws of mechanics formulated in the middle of the eighteenth century had an elegance and generality which attracted mathematicians and theoretical physicists and were far from the actual conditions encountered in practical working. In hydrodynamics, for example, for obtaining exact solutions of the equations, viscosity had been neglected. Frictionless fluids form the basis on which classical hydrodynamics is developed. In engineering hydraulics as developed by practical workers, one finds countless numerical coefficients entirely divorced from the mathematical theory of hydrodynamics and it was extremely difficult to secure generalised relations to form a rational scheme.

It was Felix Klein who first realised this defect in the outlook of engineers and began to build up a school of applied mathematics and applied physics which developed a new interest and new point of view so as to bring engineering and science closer together. Among the group of people associated with him Prandtl, Von Karman and Timoshenko are best known as

pioneers in this line. Their main effort had been in obtaining approximate solutions of more specialised equations in which all the essential physical elements of a particular problem are included.

The theory of the aircraft structures is concerned with the transmission of the air forces from the surfaces where they arise and to the useful load which they carry. The aeroplane requires a smooth strong external surface for the air pressures to act on. The external surface has to perform two functions simultaneously, namely, carrying the external pressures and serving as an integral portion of the major structure. In the most modern type of aircraft, the older types of design having a sort of skeleton structure with a covering fabric forming the external surface, have been abandoned. They have been replaced by the so-called 'monocoque' type of design in which the surface is made of thin metal and carries a considerable fraction of the major structural loads. The structural members usually have lengths which are very large compared to their transverse dimensions.

The use of the 'monocoque' construction and the great slenderness of the structural members result in tendencies towards instability or local buckling. For long compression members like struts, beam flanges, etc., the problem has been attacked in two manners. Firstly, by designing the structures so that such members have lateral support at frequent intervals. The ratio of length to transverse direction is kept fairly small between supports so that tendency for buckling is reduced. Secondly, carefully worked out cross-sectional shapes are determined so as to distribute a given amount of inertia and increased resistance to buckling. It was easily noticed that in order to prevent buckling of the struts, the thickness would have to be so great and so many stiffening elements would be necessary that the weight would be prohibitive. Wagner, after a careful study, took the bold step of conceiving structures which were allowed and even designed to develop wavy shapes under load. The structure would not buckle in normal flight but goes into a wave state during the brief instant when the loads are higher than normal. The theoretical design formula worked out by Wagner forms the basis of all modern constructions and serves their purpose well.

Turning now to the field of aerodynamics one finds that the earliest scientific analysis of this question was the work of Newton who developed a theoretical formula for the lift of a flat plate. This formula predicted that the lift should be proportional to the square of the angular inclination of the plate to the wind. From this formula, one finds that in order to obtain reasonable lifts, enormous amount of power would be required to drive the plate through air fast enough to retain this high angle of inclination. It was only near the beginning

of the present century that actual machines had been built which were capable of flying and on careful examination by the theoretical physicists, it was found that the lift of a plate was proportional to the angle of inclination rather than to the square of the angle.

The relation between the lift and the wind inclination, as well as resistance to forward motion or the drag, depend largely on the wing span, i.e., the lateral expansion of the supporting wings. Here were encountered great difficulties in design till 1911 when Prandtl worked out a purely theoretical analysis of the problem, which led to a very simple formula connecting effect of span on drag as well as the relation between the lift and wing inclination. The pressure drag which is the resultant of all normal pressures acting on the surfaces of a body moving through a fluid has been discussed by Helmholtz, Kirchoff and Rayleigh but owing to the absence of suitable data, these theoretical studies did not find successful application. In 1911 Von Karman showed that by proper 'stream lining' this pressure drag could be completely eliminated. There was yet another factor, namely, the friction encountered by the moving body in motion. This has been the subject of study by Prandtl who showed that the influence of friction was confined to a thin 'boundary layer' close to the surface of a body moving through the atmosphere.

The problem of 'stability', i.e. the disturbance effect produced by gust of wind or movements of controls on the normal flying condition, was not very clearly understood. Bryan undertook the study of this problem and arrived at a solution. Though it is highly involved, requiring extensive mathematical technique, yet it forms a basis of calculation and several approximations have now been adopted which have rendered the solution of the stability problem much more easy than before.

The question of 'turbulence' attracted some of the best brains in the world for the last fifty years and yet it remains in a state of uncertainty. Osborne Reynolds studied the subject as early as 1883 and arrived at the relation between the different types of fluid motions and their dependence on speed. The distinction between 'laminar motion' and 'turbulent flow' of a fluid and their dependence on the 'critical speed' were worked out by him. The so-called Reynolds number and a critical Reynolds number at which transition occurs from the 'laminar' to the 'turbulent' state exist for almost every type of fluid motion. It appears that in practically all cases of technical importance in aerodynamics the range of Reynolds numbers encountered lies far above the critical one, so that a knowledge of the nature of turbulent flow is of extreme practical importance.

Extensive experimental investigations to ascertain the nature of turbulent flow have been conducted. The hot wire anemo-

meter has been widely used for the purpose. Oscillograms of these records have disclosed their complicated nature and still demand careful analysis. The statistical treatment of the problem regarding the mechanism of turbulence by G. I. Taylor may prove to be a very efficient tool which will finally build up a consistent theory.

The recent researches on the aerodynamics of aircraft have attracted considerable attention of eminent applied physicists. Prof. Melville Jones of the Cambridge University has been applying with great success the Pitot-travers method for drag measurements. The measurement of the profile drag on an aeroplane wing by Relf in the compressed air tunnel at the National Physical Laboratory is of great value. In fact the experimental observations now reach up to Reynolds number value of about 24 millions, a value appropriate to the fast modern aircraft.

The co-operation between the actual observations and experimental work of the aerodynamic laboratories is now proceeding very closely. The observation of squadron leaders in actual flight are now communicated to the theoretical physicists and to those engaged in wind tunnel experiments so that effective changes in the shape, structure, and surface of the aircraft are being continually modified consistent with the above-mentioned background. There yet remains ample scope for research on numerous problems of stability and control. Oscillation problems have been treated generally on the basis that forces at issue are linear functions of velocity and displacements, whereas such factors as controlled and mechanical friction introduce non-linear relationship which has to be taken into account for safe high speed flying.

The whole aspect of aerodynamics leading to the design and construction of aeroplanes is now engaging the attention of an earnest band of workers toiling ceaselessly to obtain practical data by the application of physical principles.

Already the theme has become fairly large and it is not my intention to multiply instances so that one may realise the important rôle of applied physics in industries. I am afraid, already I have passed the limit of your patience with which you have so kindly favoured me till now. In spite of this, I cannot but draw your attention to the part which applied physics is now playing in agriculture, land survey, meteorology and biological sciences. In the different industries such as, the textile, paper, glass, rubber, abrasives and in various other industries, large and small, the unseen influences of physical methods and appliances are ceaselessly working for better production and economic development. Illumination of our highways, schools, workshops, public places of amusement indicate the useful character of the application of physics. I cannot but mention the different aspects of vibrations and

forced oscillations in its different effects, modifying our social well-being. In this connection it will not be out of place to mention a very striking example. I would like to refer to you the case of the terrible railway disaster at Bihta in 1937. It is well known that the Government of India appointed a special committee, known as the 'Pacific Locomotive Committee', to investigate the cause and suggest remedies for the future non-recurrence of such accidents. I hope all of you are aware that to study the vibrations and oscillations produced in the tracks and engines, a special observation car was fitted up by the Chief Electrical Engineer of G. I. P. Railway, Mr. Mulleneux, and the vibration recording devices designed by the French physicist and railroad engineer Hallade were requisitioned. After the systematic study over several hundred miles of tracks of the behaviour of this special pacific locomotive XB and XA classes of engine, the Committee recommended certain modifications and additions to the engine for its safe running. It was further suggested by the Committee that an enlarged organisation for research and standards should be taken up by the Railway Board to determine the actual vibration and oscillation conditions in tracks and locomotives all over India to ensure their safe running.

Last but not the least is the contribution of applied physics to industries in the different 'Measuring Instruments'. Thus in our land survey from the simple measuring chain to the modern aerial photographs for the contour survey of inaccessible region are but examples of its utility. For the control of every industrial process, the measurement of pressure, force, energy, frequency and numerous other mechanisms are finding place. For interchangeable part of machinery and equipment, precision gauges, jigs, ruling engines, projection devices are becoming more and more evident. The measurement of temperature is an important factor in our daily life and the use of temperature measuring devices such as the thermometers, and the different classes of recording and non-recording pyrometers are becoming absolutely essential in the industry. Regarding electrical instruments, apart from voltmeters, ammeters, energy-meters, frequency-meters and power-factor meters, which are practically developments in one form or other of the galvanometers used in laboratories, one finds a large variety of instruments with modifications suitable for the purpose to which they are to be applied. The steady growth of radio and broadcasting and that of the aircraft created a demand for numerous types of measuring instruments which are primarily born in laboratory but put to industrial use in its multifarious forms. Finally, I would say that the contribution of applied physics to other sciences and to industries is becoming increasingly felt and it is expected that in the near future as time progresses, there would be greater and greater demand for applied physicists in industry.

SECTION OF CHEMISTRY

President :—MATA PRASAD, D.Sc., F.I.C., F.N.I.

Presidential Address

(*Delivered on Jan. 3, 1941*)

PHYSICO-CHEMICAL STUDIES OF GELS

In the great science of the structure of matter the science of colloids represents the domain which lies above the molecular and below the macroscopic dimensions. In this domain there lie a number of systems which form the basis of essential material processes affecting life as a whole. Considerable advance has taken place in our knowledge about these systems during recent years and these have opened up the possibilities of wide and far-reaching applications of this branch of chemistry in both theoretical and practical sciences.

In this address I propose to deal with one of the numerous systems of colloids, namely, the 'gels' in which I have been interested for the last fifteen years. The name 'gel' was first introduced by Thomas Graham, the founder of colloidal chemistry, to designate the precipitate formed on the addition of electrolytes to colloidal solutions or what are commonly known as sols. This term has now acquired quite a different meaning. According to Freundlich [1] colloidally disperse structures consisting of a solid and a liquid phase or of two liquid phases, and having shape and cohesion, that is, elastic properties, should be called 'gels'. However, some authors have preferred to use the term 'jelley' for elastic gels in which the amount of the enclosed liquid is relatively enormous. McBain [2] holds the view that those jellies which differ from sols in elastic properties only should be considered as gels, but the number of such systems which are so alike in the sol and gel states is very small. Further, McBain's definition excludes a number of systems which have been described as gels by several writers and are of great scientific and industrial importance. Thus it seems that it is not quite easy to put forward a definition so comprehensive as to include all the known gels within its scope. The definition given by Freundlich has been adopted by the writer throughout the present discourse.

The earliest known gels were those of gelatin and silicic acid. The former were obtained in transparent and elastic state and were heat reversible while the latter were known to

be opaque and were considered to be inelastic. These characteristics have given rise to classification of gels into various divisions such as transparent and opaque, elastic and rigid, and heat reversible and heat irreversible. Although many of these divisions have gone out of vogue, the one between organic and inorganic, determined by the nature of the substance in the gel condition, is still retained. If we accept this classification there is need for introducing another division to include gels prepared from inorganic salts of organic acids. These could be called inorgano-organic or organo-inorganic gels, not only on account of the nature of the substance in the gel state, but also from the consideration that some of the characteristics of this type of gels are allied to those of truly organic gels while other properties are related to the truly inorganic ones.

ORGANIC GELS

Earliest known gels belonging to this class are those of gelatin and agar-agar. These are fairly complex organic substances derived from animal and vegetable matter, respectively, and are made up of an unknown number of unisolated chemical entities. Gels of pectin derived from several fruits are also quite well known. Recently, gels of cellulose acetate and of geranin and viscose, which are substances of no less complexity, have been prepared by Mardles [3] and Liepatoff [4]. Nevertheless, literature abounds in the description of gels of several definite organic substances, some of which exist in crystalline form. The gels of these substances have been obtained either in aqueous medium or in some suitable organic solvent. Glycyrrhizic acid [5], camphoryl phenyl thiosemicarbazide [6], azomethine [7], dibenzoic acetal of sorbitol [8], benzopyrone derivatives [9], benzopurpurin 4B, and crysophenin B [10] can be cited as a few instances.

The usual procedure adopted for the preparation of these gels consists in preparing a solution of the gelling substance in a solvent at a high temperature and then allowing this solution to cool either slowly or rapidly. Instances are, however, known which show that the procedure described above is not applicable to the formation of all organic gels. Thus, for example, solutions of nitro-cellulose [11] in a mixture of amyl acetate and benzine, of nitro-cotton [12] in alcohol and of methyl cellulose [13] in water, have been found to gelatinise on heating. Further, it has been found that neither heating nor cooling is necessary for the formation of gels of dibenzoyl cystine [14]. These are prepared by merely dissolving the crystals of the substance in alcohol and pouring the solution into water.

INORGANO-ORGANIC GELS

Several gels belonging to this class are known and while some of them have been prepared in organic solvents, others

are easily obtained in aqueous medium. Gels of barium malonate [15] form a good example of the former type. They are prepared by mixing solutions of suitable concentrations of barium hydroxide and malonic acid in methyl alcohol in the presence of certain amount of glycerine. Gels of lithium urate [16] and those of soaps are best instances of the latter type. Considerable amount of work has been done by McBain and co-workers [2] on aqueous solutions of alkali salts of higher fatty acids. To these they have given the special name of colloidal electrolytes. They have shown that an aqueous solution of sodium oleate can be brought in any of the three typical colloidal states, namely, clear oily liquid sol, white opaque solid curd, and clear transparent elastic gel. Gels containing a low amount of sodium oleate are obtained by very slow warming of the curd while those of high soap content are prepared by cooling the sol.

Soap gels have also been prepared in non-aqueous media. Fischer [17] obtained a non-syneretic gel of sodium arachidate in methyl alcohol and Miss Laing and McBain [18] prepared gels of potassium and sodium soaps in alcohol-water mixtures. Recently, it has been found at the Royal Institute of Science [19] that sodium and potassium salts of oleic, stearic and palmitic acids dissolve easily in pinene at about 140° and the resulting solutions set to transparent colourless gels when cooled to room temperature. All these gels are heat reversible and some of them show the phenomenon of syneresis.

INORGANIC GELS

The earliest known gel belonging to this class is that of silicic acid. This has been prepared by several workers usually by the action of acids, organic and inorganic, upon sodium silicate. Bhatnagar and Mathur [20] showed that these gels can be very conveniently obtained by mixing suitable solutions of sodium silicate and ammonium acetate. In recent years, a large number of gels of inorganic substances have been prepared and some of them have been obtained in as transparent a state as the organic gels. An account of the preparation of gels of hydroxides, phosphates, arsenates, molybdates, etc., of several metals is given by Satya Prakash [21] who has himself prepared several of these gels for the first time. The methods employed for the preparation of these gels can be classified as follows:—

(1) By mixing the constituents of the gel-forming mixture. In some cases, this results in the formation of a clear solution which goes over to the colloidal state, and in other cases, a precipitate is formed and it disappears on slight or vigorous shaking.

(2) By the addition of electrolytes to a fairly concentrated and suitably dialyzed sol of the gelling substance, or by the prolonged dialysis of such a sol.

(3) By changing the solvent or by the dilution of a true solution of the gelling substance which is sparingly soluble in the changed or the diluted solvent.

The hydrogen-ion concentration of mixtures giving rise to inorganic gels exerts a profound influence on the nature, the appearance and the characteristics of the gel. It has been found in the case of silicic acid that using the same solution of sodium silicate and different solutions of acidic ammonium acetate, two types of gels are obtained, one in the alkaline medium and the other in the acidic one [22]. Not only is the mode of formation of these two gels different, but they also differ from each other in appearance, the one formed from acidic medium being more or less transparent. The results of this investigation have led to the preparation [23] in a transparent state, of a number of inorganic gels which had been obtained previously only in an opaque or translucent condition. For this purpose acids instead of alkali salts of the acids corresponding to the acidic radicals of the gel-forming substance have been employed, wherever possible, and, if necessary, suitable amounts of hydrochloric acid have been added to the gel-forming mixtures.

Sol-gel transformation

The sol-gel transformation is irreversible in some cases, while in other cases, a gel can be converted into a sol and back to gel any number of times at will. The reversible sol-gel transformation in the case of organic and some inorgano-organic gels is brought about by heating or cooling and is called non-isothermal reversible transformation.

Recently, Szegvari and Miss Schalek [24] discovered that gels of iron hydroxide show the phenomenon of isothermal reversible sol-gel transformation which has been named thixotropy. A thixotropic gel goes over to the sol state by mere shaking or stirring or by some mechanical action or under the influence of ultrasonic waves and sets again to the gel state when left to itself. This process can be repeated at will. Gels of aluminium hydroxide, vanadium pentoxide, thorium molybdate, thorium arsenate, are some of the many instances of thixotropic gels. The thixotropic change, in some cases, is accompanied by reversible changes of colour; for example, the iron oxide sol to which sodium chloride is added, appears golden brown and clear while the gel looks yellow and turbid [25].

It has been observed by Prakash [26] that if gels of ferric phosphate and arsenate, thorium molybdate and phosphate and aluminium and zirconium hydroxide are frozen in liquid air and brought to room temperature, a sol is again formed which sets to a gel after a time. This process of reversible sol-gel transformation can be repeated at will. He has named this phenomenon as cryotropy.

A new kind of reversible sol-gel transformation has been found by my collaborators and myself [23, 27] with gels of thorium phosphate and arsenate prepared from thorium nitrate and phosphoric and arsenic acids, respectively. They go over first to the sol state and then into solution when desiccated over calcium chloride and reset to a gel when the necessary amount of water is added to the solution. A similar behaviour was observed by Freundlich with iron oxide sol which sets to a thixotropic gel on the addition of alcohol and the gel is reconverted to a sol when desiccated over water [24].

MICROSCOPIC INVESTIGATIONS

The scientific mind is not content with the mere preparation of a substance and observing the transformation it undergoes; it strives to probe deeper and search for its constitution. It is, therefore, not surprising to find that even in the early days of the development of this subject the attention of some investigators was directed to various enquiries regarding the internal structure of gels, such as, the size and shape of the ultimate particles of which a gel is composed, the mechanism by which a system containing only a small amount of the solid matter and a large volume of the liquid phase gives rise to a solid-looking substance, the manner in which the liquid phase is held in the gel system and several other aspects.

To answer these questions attempts were made in the beginning to observe the structure by means of a microscope and an ultra-microscope. The microscopic examination by Hardy [28] of a solution of gelatin undergoing gelation revealed that when the solution is cooled below 20°, a cloudiness first appears, due to the formation of fluid droplets which, on further cooling, solidify and adhere to one another. Zsigmondy [29] examined ultra-microscopically the dry gels of silicic acid as well as those filled with liquid, and found that they were mostly optically empty. However, on drying the gel, he could obtain some evidence of the existence of submicrons. Bachmann [30] also followed the gelation of silicic acid, gelatin and agar sol through an ultra-microscope. In a one per cent solution of gelatin he observed that some time after the solution is made, there appears a crowd of submicrons in lively movement which ceases when the gel is set.

The above are the only few instances in which results of any significance have been obtained. In the case of other gels the microscopic and ultra-microscopic examinations have revealed no structure but have only indicated that the particles in gels are too fine to be seen by these instruments and hence their diameters are of the same order of magnitude as the wave-length of light. This is due to the fact that the application of these instruments to the study of gels has several limitations. For

example, if the particles are too small to be optically resolved or too numerous or if the difference between the refractive indices of the particles and the dispersion medium is inappreciable, only uniform illumination is seen instead of diffraction images due to the particles.

Recently, the newly discovered electron microscope has been employed for the determination of the shape of particles in the sol condition. Beischer and Krause [31] have found that the particles in a gold sol are cubical and those in an iron sol are thread-like. No application of this instrument for determining the shape of particles of substances in the gel state has so far been reported.

Properties of gels

As no results of definite character regarding the gel structure could be obtained by direct examination, the workers in this field took to a systematic study of the various properties of gels and the changes which they undergo during the process of gelation or sol-gel transformation. It is no exaggeration to say that the great bulk of information of immense significance in postulating theories of structure of gels has been indirectly derived from such a study. An account, which is by no means complete, of the important results obtained from some of these investigations is given in the following pages.

(A) Time of setting

The time of setting is the main property which characterizes a gel. Various workers have employed different criteria for the setting of a gel. The general consensus of opinion is inclined to the view that the attainment of a certain viscosity by the gel-forming mixture should be employed as the criterion for the setting of a gel. But such a criterion gives only a relative and not an absolute value of the time of setting. Further, it implies that all changes involved in the process of gelation are completed during this period. This is not entirely correct.

Methods which have been employed so far for the determination of the time of setting are as follows:—

(1) Fleming's method [32] which consists in determining the time which a gel-forming mixture takes to reach a consistency which will prevent it from flowing out of its container.

(2) Fells and Firth's method [33] depends upon the criterion that the pressure required to blow a bubble of air or of mercury or of chloroform through a gel-forming mixture reaches a maximum value at the time of setting.

(3) Hurd and Letteron's method [34] consists in placing a rod in the gel-forming mixture in a certain position by the help of a suitable support and the time which the mixture takes to reach a state when the rod can remain in this position without the support, is the time of setting.

(4) Prasad and Hattiangadi's method [22] involves the measurement in the changes in the intensity of light from a constant source transmitted through the gel-forming mixture. The gel is considered to have set when these changes reach a constant value.

The measurement of the time of setting of the same gel-forming mixture by the above-mentioned methods has given values which are widely different from each other [35], and hence has experimentally confirmed the view concerning the usefulness of these methods for comparative studies only.

Most of the work on the time of setting has been done on inorganic gels, mainly at Allahabad, at the Royal Institute of Science, Bombay, and by Hurd and co-workers. The latter workers are to be credited for giving the time of setting the importance which it deserves. They [36] assume that the setting of a gel is a process which follows the laws of ordinary chemical reactions, so far as its velocity is concerned, and that for a given run, the time of setting measures the time when a certain fixed proportion of silica, in whatever form, has reacted. On the basis of these assumptions they have extended the application of Arrhenius's equation to the setting of silicic acid gels and, in agreement with the requirements of this equation, have found that the curves obtained on plotting the logarithm of the time of setting against the reciprocal of absolute temperature are straight lines. The heat of activation of silicic acid gel calculated from this data has been found to be independent of the nature of the acid used for the preparation of the gel. These investigations thus point out the importance of temperature control in the determination of the time of setting of gels.

The assumptions mentioned above have been found to apply equally well to other inorganic gels studied by Prasad and co-workers [23]. The time of setting of the gels has been found to decrease with rise of temperature but the heats of activation have been found to alter with a change in the concentrations of the constituents of the gel-forming mixtures. In some cases, particularly in the case of gels of thorium arsenate, the time of setting has been found to increase with temperature and the heat of activation is negative.

Similar measurements in the case of organic gels are not possible since they would not set at temperatures at which the solutions are made. Hence a considerable time would be lost and a part of the setting process would be completed before these solutions are brought to setting temperatures. In such cases we have suggested [37] that the time required by a gel-forming solution to set to the gel state when it is allowed to cool from a certain high temperature to a known lower temperature, may be taken as the time of setting of the gel at the lower temperature. Probably the same procedure has been followed by Olsen [39] who studied the time of setting of gelatin gels at

various temperatures. A study of the cooling curves of solutions of sodium oleate in pinene [38] has revealed that the time taken by these solutions to cool down to the temperature of the bath (lower temperature) is a considerable fraction of the time of setting in accordance with the definition given above. Sufficient data are not yet available to draw conclusive inferences regarding the applicability of Arrhenius's equation to all organic gels. However, in several cases [37] straight lines have been obtained on plotting the logarithm of the time of setting against the reciprocal of the absolute temperature. These straight lines show that the heat of activation of these gels is negative and their time of setting increases as the temperature of setting is raised.

Thixotropic gels are characterized by a second time of setting which is called 'thixotropic time of set'. This is shorter than the proper time of setting of gels and is the time taken by thixotropic gels to set after they have been liquefied by some mechanical action. It is remarkable that this time has practically constant value, that is, it can be repeated as often as one likes, and is independent of the agency employed for bringing the gel into the sol state. This gives only an arbitrary way of defining thixotropy.

It has been observed that the time of setting of an aged thixotropic vanadium pentoxide sol is reduced to one-fourth if the tube containing the sol is given a rotatory motion backwards and forwards by moving it between the palms of the hands. This phenomenon has been called 'Rheopexy' by Freundlich and Juliusburger [40].

The time of setting of gels is considerably altered by the changes in the concentration of the gel-forming substance or of the constituents of the gel-forming mixtures. In the former case the setting time decreases with an increase in the concentration but in the latter, it usually increases with an increase in the concentration of the constituent containing the metal ion of the gel-forming substance and decreases with an increase in the concentration of the other constituent. In the case of silicic acid gels prepared according to Bhatnagar and Mathur's method it has been found that with an increase in the concentration of acidic ammonium acetate the time of setting first decreases, reaches a minimum value, then increases and reaches a maximum value and again decreases [22]. Similar observations have been made in the case of some other gels as well [23].

The time of setting of a gel has been found to depend specifically upon the hydrogen-ion concentration of the gel-forming mixture. Freundlich and Sollner [41] have found that the time of setting of an iron hydroxide sol increases from 82 seconds to 9,000 seconds when the pH is changed from 3·86 to 3·11. The effect of hydrogen-ion concentration has been exhaustively studied by Hurd and co-workers [42] in the case of the silicic acid gels. They find that a linear relationship holds

between the time of setting and the hydrogen-ion concentration. Hurd and Paton [43] have, in a recent publication, confirmed in a remarkable manner the specificity of the effect of *p*H upon the time of setting. On adding the same amount of acetic acid to the same silicic acid gel-forming mixture at different intervals from the commencement of the formation of the gel, they have shown that the setting of the gel proceeds at the same rate as without the addition of the acid for the time before the acid is added and subsequently at the rate followed in the presence of the acid added at the commencement of the setting. It has been recently found that an approximately linear relation also exists between the time of setting and the hydroxyl-ion concentration of alkaline silicic acid gel-forming mixtures.

Results of similar investigations on the time of setting of thorium arsenate and thorium phosphate gels by Desai and Miss Nathan [44] at the Royal Instiute of Science, have shown no linear relationship between the time of setting, determined by Hurd and Letteron's method, and the excess of hydrochloric acid added to the gel-forming mixtures. They find that with an increase in the amount of the acid in the gel-forming mixtures, the time of setting first decreases and then increases.

The time of setting of gels is very sensitive to the addition of small amounts of electrolytes and non-electrolytes. The effect of these agents was first systematically studied by Prasad and Hattiangadi [45]. They showed that the time of setting of alkaline silicic acid gels decreases while that of acidic ones increases on the addition of various alcohols to the gel-forming mixtures. This work has been extended by Hurd and Carver [46] and Munro and co-workers [47] who have examined the effect of several polyhydric alcohols, sugars, acetone and aldehyde, on the time of setting of silicic acid gels, and by Prasad and Desai [48] to the case of several transparent inorganic gels prepared by them.

Thixotropic time of setting is also influenced by changes in (i) the concentrations of the coagulating agents or of the constituents of the gel-forming mixtures, and (ii) the hydrogen-ion concentration of the gel-forming system, and (iii) by the addition of non-electrolytes. A change of temperature also alters the thixotropic time of setting and the changes are governed by Arrhenius's equation [49].

(B) Elasticity

The next property which is characteristic of the gel state alone is elasticity. The importance of this property was recognized even in the early days but its significance in elucidating the structure of gels has been understood only recently. Most of the work on the measurement of modulus of elasticity has been conducted on organic gels, particularly on the gels of gelatin which have been found to follow Hooke's law [50] and the modulus has been shown to vary as the square of the

concentration [51]. Recent measurements by Hatschek [52] with a highly improved apparatus have shown that the gels containing 8–12 % of gelatin have a well-defined modulus up to a load corresponding to 45 g. per sq.cm., and this value is repeatable within about 3 per cent.

The value of the modulus has been found to change with a change in the quality of the gelatin and the hydrogen-ion concentration of the gel-forming system. Freundlich and Neukirchu [53] found a minimum in the neighbourhood of the isoelectric *p*H while Kunitz [54] found that acids and alkali strongly reduce the elastic modulus of the swelling gels. The modulus is also altered by the addition of substances like alcohol, sugars, glycerol and inorganic salts, to the gelatin gels. Poole [55] has shown recently that the extension of a rod of gelatin gel increases with time and that the elasticity of the gel also varies with temperature. The strain produced in the gel causes double refraction which is roughly proportional to the concentration.

Some observations have been reported on the measurement of elasticity of gels of cellulose acetate by Mardles in 1923. The systematic work on these gels has been carried out by Poole [56] who finds that the elasticity of these gels also varies with time and temperature and approximately as the square of the concentration.

No systematic work of this nature has been done on silicic acid gels which have been considered as inelastic. The measurement of the elasticity of compressed silicic acid gels by the writer [57] has revealed that they obey Hooke's law up to the breaking point but the elastic limit is low. The elasticity of several other inorganic gels has been measured by Yajnik and collaborators [58].

Gels of silicic acid emit a peculiar note when they are suitably made to vibrate. The sonorous property of these gels has been noticed by several workers and has been studied systematically by Holmes, Kaufmann and Nicholas [59] with gels contained in tubes. The writer measured the velocity of sound in the compressed gels and found that the elasticity calculated from the relation applicable to isotropic solids is in fair agreement with the experimental value [57].

(C) Viscosity

Several references have been made to the effect that elasticity is related to viscosity, but no definite mathematical expression of general application correlating the two constants has so far been put forward. Notwithstanding this view, the importance of viscosity as a characteristic property of a colloidal system was recognized by Graham who was the first to suggest that the viscometer should be employed as colloidoscope. Wolfgang Ostwald while inaugurating a General Discussion on Colloids and their Viscosity under the auspices of the Faraday Society

stated in his introductory address, 'The determination of viscosity is a prominent methodic principle in investigating the properties of the colloidal systems which are usually described as changes of state'. Further, he mentioned, 'Among all the properties, viscosity occupies a central position, firstly because it shows the largest possible variation with small changes in the colloidal condition' and secondly because it 'permits quantitative measurements . . . by a method not too complicated'.

Usually, the viscosity of a system undergoing gel-formation has been measured by the flow of the gel-forming mixture through a capillary tube (Ostwald's and Scarpa's methods). Mardles [60] has systematically studied the effect of the diameter of the capillary tube on the viscosity-time curves obtained during the formation of cellulose acetate gels in benzyl alcohol and has also employed rotating cylinder and falling sphere viscometers for these measurements. He finds distinct differences in several measurements and concludes, 'with gelating sols the viscosity values have lost their usual significance and are empirical but they are valuable in that they indicate the progress of gelation'.

Earlier measurements of viscosity during gel-formation were done mostly on gelatin solutions and some empirical relations between changes in viscosity with time were found out. The results obtained during the gelation of solutions of cellulose acetate in benzyl alcohol (Mardles) could be expressed in the form of an exponential equation which shows that the rate of increase of viscosity with time is proportional to the increase of viscosity at that time. This relation has also been found to hold for the viscosity changes with time in silicic acid gel-forming mixtures [61] and solutions of sodium oleate in pinene [62] but is not obeyed in the case of other inorganic gels.

Prakash and Dhar [63] have measured the viscosities of several gels during setting and have shown that their results indicate three distinct stages during the process of the formation of gels. The viscosity measurements carried out at the Royal Institute of Science [64], have failed to show these stages and hence it has been suggested that if they exist at all, they run simultaneously and lend to the whole process of gelation an aspect of continuity. It has been noted in all the studies that the viscosity increases only slowly in the earlier stages but after some time the rate of increase of viscosity becomes very rapid.

Changes in viscosity of inorganic gel-forming mixtures during setting are considerably modified by changes in the concentrations of the constituents of the gel-forming mixtures, the addition of extra amounts of electrolytes and non-electrolytes, and temperature. It has generally been found that an increase in the concentration of the metallic ion of the inorganic gel-forming substance decreases the rate of increase of viscosity while an increase in the concentration of the other ion increases

it. It has been suggested that in the former case there is an increase in the density of charge on the particles of the gel-forming substance and hence an increase in its degree of dispersity and a decrease in the degree of hydration [65].

The addition of alcohols has been generally found to retard the rate of increase of viscosity with time in acidic silicic acid gel-forming mixtures and the reverse happens in the alkaline ones [66]. Similar effects have been observed with gels of thorium phosphate, thorium arsenate and stannic phosphate. The effect of the addition of increasing amounts of hydrochloric acid has been studied by Miss Nathan who finds that the rate of change of viscosity with time increases up to a certain amount only; further additions effect a decrease in the viscosity changes.

Increase of temperature increases the rate of increase of viscosity with time for all the inorganic gel-forming mixtures studied so far, thorium arsenate being the only exception to the above rule. The reverse effect takes place on the viscosity changes with time in the case of the organic gels, on rise of temperature.

The study of the change of 'viscous behaviour' has also been suggested by Freundlich as the best method of attacking the problem of thixotropy in a quantitative manner. Viscosity measurements during the setting of thixotropic gels of thorium molybdate [67] and of stannic hydroxide by capillary viscometer have yielded viscosity-time curves which are discontinuous or zonal as named by Joshi and co-workers [68] who were the first to obtain zonal viscosity-time curves during the studies of the coagulation of several colloidal solutions by electrolytes carried out at the laboratories of the Hindu University. The nature of zones in these curves has been found to change with a variation in (i) the concentrations of the constituents of the gel-forming mixtures, (ii) the hydrogen-ion concentration, and (iii) temperature, and (iv) by the addition of extra amounts of electrolytes and non-electrolytes. Such curves have not been obtained in the case of thorium arsenate gels [64] which are also known to be thixotropic. Hence it has been suggested by us that the zonal nature of the viscosity-time curves may be taken as a characteristic of highly thixotropic gels only.

Goodeve and Whitefield [69] have shown that for quantitative work it is necessary to determine the resistance to flow, that is, the rate of increase of viscosity under constant shear in a fairly short time—a condition which is not reached in the usual methods employed for the measurement of viscosity. According to them under conditions of steady shear there is an equilibrium between the rate of increase of the concentration of the micelles and the rate of their breakdown, and the apparent viscosity η of the system is given by

$$\eta = \eta_0 + \frac{\theta}{S}$$

where η_0 is the residual viscosity, S the shear, and θ the *coefficient of thixotropy* which may be stated as the rate of growth of structural viscosity with time divided by the probability of the viscosity being broken down in unit time by unit shear. They have devised an apparatus for the measurement of the apparent viscosity of a thixotropic system at different rates of shear and have shown that the curves obtained on plotting the observed values of viscosity against the reciprocal of shear are straight lines at high rates of shear and are independent of the rate of shear. The limiting slopes of these lines are the coefficients of thixotropy. Measurements made on thixotropic suspensions have yielded results which are in conformity with the theory but no such work has so far been carried out on thixotropic gels considered in this discourse.

(D) Optical Properties

The study of the optical properties of gels has a great advantage over the viscosity as in this case the observation can be made without disturbing the internal equilibrium of the system. Optical properties which have been studied during the process of gel-formation include mainly (1) the scattering of light and its polarization, (2) refractive index, (3) extinction coefficient, (4) turbidity, transparency or opacity.

The method of scattering of light was first developed by Lord Rayleigh [70] with a view to obtain information regarding the size and shape of colloidal particles and the colour changes which accompany the coagulation of sols by electrolytes. Arisz [71] extended this method to the study of the transformation of the glycerol sols of gelatin to the gel state and found that the rate of change of the intensity of scattered light increases rapidly with temperature during gelation. Kraemer and Dexter [72] also found an abrupt rise in the intensity of the light scattered by gelatin solutions at temperatures below 30° within a very narrow range of *p*H near the isoelectric point. Duclaux and Hirata [73] have, however, pointed out that this increase is not due to an increase in the volume of the gelling elements but is caused by the formation of a network.

Effects of various factors which influence the process of gelation, on the intensity of scattered light, expressed in the form of the Tyndall number, have been systematically investigated by Mardles [74] during the reversible sol-gel transformation of cellulose acetate in benzyl alcohol. He finds that the Tyndall number is a function of the mechanical treatment and the rate of gelation. Further, it varies with time, temperature and the concentration of cellulose acetate. The Tyndall number-temperature curves reveal the existence of a maximum gelation temperature while the Tyndall number-concentration curves contain a maximum which decreases with rise of temperature.

The measurements of intensity and depolarization of scattered light have also been made during the reversible sol-gel transformation of agar-agar by Krishnamurti [75] whose results also point to the existence of a maximum gelation temperature. Further he finds that there is practically no change in the Tyndall number with time at and above 40°, but at and below 35° it increases with time until a constant value is reached, and that the particles in the gel state are bigger or greater or both than in the sol state.

A new aspect of the subject of scattering of light by colloids has been developed recently in the laboratories of Professor Sir C. V. Raman. Subbaramiah and Krishnan [76] have shown that in order to obtain information regarding the size and shape of particles in the colloidal state it is not sufficient to measure only the intensity and depolarization of the scattered light. They suggest that it is necessary to obtain the values of the depolarization factors (ρ_u, ρ_v, ρ_h) for the light transversely scattered by a colloidal system with incident light unpolarized, vertically polarized and horizontally polarized. The application of this method has been extended by Subba Ramaiah to the study of the phenomenon during the sol-gel transformation of silicic acid, stearic acid and sodium stearate[77]. He finds that a continuous increase in the micellar size takes place during the sol-gel transformation of silicic acid and this increase continues even after the formation of a rigid gel. The micellar size is greater in alkaline gels than in the acidic ones of the same concentration.

Refractive index measurements of systems which set to a gel have been made by a number of workers in the sol and the gel states mainly with a view to determine the transition temperature. Miss Laing and McBain [2] employed this method to examine the nature of aqueous solutions of sodium oleate in the three characteristic colloidal states and found that the sol and the gel forms are identical with respect to the refractive index.

Mardles [78] obtained indications of change of refractive index during the reversible sol to gel transition of cellulose acetate in benzyl alcohol. Mathur [79] also found that the refractive index increases rapidly as a solution of sodium oleate in pinene is cooled and reaches almost a constant value when the gel is set. The refractive index changes considerably with the temperature of setting but with the change in concentration of sodium oleate the effect on the refractive index is not appreciable.

No work seems to have been done on the changes in the refractive index of the inorganic gel-forming mixtures during the process of gelation. Some observations have been taken during the setting of a few gels and it has been found that this property does not undergo any appreciable change during the gelation process. However, Joshi and co-workers [80] who are the first to employ the refractive index method for the study of

the kinetics of the coagulation of sols by electrolytes have found zonal changes in this property with time.

The measurement of the extinction coefficient during the process of gelation seems to have been done mainly by Prasad and co-workers [81] and Prakash [82]. The former studied the changes in the extinction coefficient of silicic acid gel-forming mixtures during setting and found that the extinction coefficient-time curves for the acidic mixtures are S-shaped while those for the alkaline mixtures are smooth rising ones. Prakash has examined several other inorganic gels by this method.

The transparency or opacity method was first introduced by Mukherjee and co-workers [83] for the study of the kinetics of coagulation of sols by electrolytes. In their earlier work they measured the changes in the intensity of light transmitted through the coagulating system in various spectral regions but later on these changes were measured by means of a thermopile which was subsequently substituted by a photo-cell by Desai and co-workers [84]. The thermopile method was employed by Prasad and Hattiangadi [22] to study the kinetics of the formation of silicic acid gels. They found that the curves obtained on plotting the deflection differences against time are smooth and hence confirmed that gelation is one continuous process. The deflection differences reach a constant value after some time, which they take to be the time of setting of the gel. The changes in the deflection differences at various intervals have been found to be remarkably influenced by the alkalinity or acidity of the mixtures and the addition of non-electrolytes and electrolytes.

Desai's photo-cell method has been recently modified by Prasad and Modak [85] who have magnified the deflections of the galvanometer several times so that even the minutest changes in the intensity of the transmitted light may not go unnoticed. Employing this arrangement for the study of changes accompanying the process of gelation of stannic phosphate and zirconium hydroxide gels they find that the opacity-time curves are smooth S-shaped and these get shifted by a change in the concentration of solutions employed for the formation of gels. The probability of any error creeping in the above arrangement due to fluctuations of the current feeding the source of light and of the voltage applied to photo-cell, has been removed in the apparatus recently devised by Gogate [86] at the Royal Institute of Science. Further, by using a compensated photo-cell system this apparatus has been adapted to read directly the opacity changes taking place in a gelating system during setting

(E) Syneresis, Drying, Imbibition, Hysteresis in Sorption and Swelling

Some gels exhibit the property of exuding liquid when they are allowed to stand for some time. This phenomenon

which is known by the name of syneresis was first observed with gels of silicic acid [87] but later on Ostwald [88] pointed out that it is shown by gels of nearly all substances which have widely different properties. The liquid exuded during the syneresis of geranin gels has been examined by Liepatoff [89] and is found to consist of small quantities of the dye which is present as single or double molecules.

The velocity of syneresis has been quantitatively studied by Liepatoff [89], Mukoyama [90], Fergusson and Appleby [91], Bonnel [92], Mathur [93] and others. For this purpose different methods have been employed to determine the amount of liquid exuded by a gel at different intervals of time. The influence of various factors, such as, the free surface, the concentrations of the constituents of the gel-forming mixture, the hydrogen-ion concentration, the presence of the added electrolytes and non-electrolytes, the temperature and other factors, on the syneresis has been exhaustively studied by some of the workers mentioned above and by Prakash and Dhar [94]. The results obtained have been critically examined by Kuhn [95] who concludes that certain gels show increased syneresis with increasing concentration whilst other gels behave in the reverse way. But there is no general rule regarding the influence of temperature on the degree of syneresis which is very sensitive to the presence of small amounts of additive agents. In general the syneresis is greater when the gel is in the least stable state.

The liquid contained in the gel can be removed by the process of drying or desorption. The first important investigation on the drying of gels was made by Van Bemmelen [96] whose experiments are considered as classical on the subject. He determined the loss of water suffered by silicic acid gels when they are dried to extreme limits and found that the contraction in volume of the gel is accompanied by changes in its transparency. Bemmelen's method of study was improved by Anderson [97] and Zsigmondy and co-workers [98] who observed changes of direction in curves obtained on plotting the amount of water held by one gram of silica against vapour pressure of the gel, at stages corresponding to the changes in its opacity. Further, they developed a mathematical expression to calculate the radii of capillaries in the silicic gel at different stages during drying. Similar investigations have been made on gels of several metal oxides. Desai [99] has shown that the rate of loss of water by silicic acid gels is least with neutral ones and increases with an increase in the acidity or the alkalinity of the gel-forming mixtures.

Fells and Firth [100] observed that when the rod of a gel of silicic acid prepared from sodium silicate and hydrochloric acid is allowed to dry under certain conditions, it contracts in volume and is surrounded by fine long needles jutting out of the dried rod. On analysis these were found to consist of sodium chloride

and their X-ray examination revealed that they possessed nearly the same structure as observed in perfect crystals.

The behaviour of gelatin gels on drying has been found to be different from that mentioned above. These gels shrink but do not show any changes in opacity at any stage during drying and there is no evidence of pores developing in the dried gel. Hatschek [101] has made an interesting study of the drying of gelatin gels made into various shapes and permanently deformed or bent before drying. He finds that drying increases the torsion considerably and a cylinder containing 10 to 15% gelatin first assumes the shape of a barrel with convex ends and finally that of a single shell hyperboloid with concave ends.

The dried gels of silicic acids and of other metal oxides, take up gases and vapours of liquids and although the amount sorped is in equilibrium with the pressure of the gas or the vapour, the sorption (hydration) isothermal is distinctly lower than that observed during desorption (dehydration), that is, the liquid content of the gel at any given pressure is smaller during sorption than during desorption. This has given rise to the phenomenon of hysteresis in sorption. The existence of the hysteresis loop has been observed by Van Bemmelen [96], Zsigmondy [98], Anderson [97], Allmand and co-workers [102], McBain [103], Foster [104] and several others and some of them have shown that hysteresis is real and persists even after drastic degassing of the gel surface. Recently, this phenomenon has been exhaustively studied by Subba Rao [105] by means of McBain-Baker quartz fibre spring balance with dried silica and metal oxide gels which were suitably activated. He has shown that the loop is a permanent one and is reproducible any number of times. Thus, for example, he has reproduced the loop in silica gel-water at the 19th cycle and in titania gel-water at the 32nd cycle. Further, he has succeeded in scanning the loops by traversing them from various intermediate points on the main sorption and desorption curves and has thus established the permanency and the reproducibility of the hysteric loops.

A similar study has been made by Subba Rao [106] of rice-water, dhal-water, gum arabic-water systems which also exhibit the phenomenon of hysteresis initially but the loop disappears on progressive sorption and desorption. However, a series of sorptions and desorptions of carbon tetrachloride by the activated rice grain shows a permanent and reproducible hysteresis loop.

The imbibition of water by gels of gelatin and of some other substances is accompanied by an increase in volume and is called swelling. A considerable information is available regarding the velocity of swelling of gels and the properties exhibited by the swollen gels. Thus, for example, it is known that an appreciable amount of heat is evolved during swelling and the swollen gels exert a pressure (swelling pressure) which is fairly high and is related to the concentration of the disperse phase. An extensive

investigation by Proctor and collaborators[107] has revealed that the swollen gelatin gels consist of two forms of gelatin, the unionized isoelectric gelatin and the ionized salt which may be gelatin hydrochlorides or sodium gelatinates.

The amount of water taken up by gelatin gels not only depends upon its concentration and its previous history but also upon the hydrogen-ion concentration of the solution from which imbibition takes place. Kunitz[108] has shown that gelatin gels, up to ten per cent concentration, contract when placed in a solution of *p*H 4·7 but swell if the concentration of the gel is greater. He considers that the shrinkage in water is similar in nature to syneresis and suggests that the two phenomena should be considered as synonymous. Hardy[109] has suggested that the exudation of liquids by gels should be considered as positive syneresis and the imbibition as negative syneresis.

(F) Diffusion and Chemical reaction in gels

Early workers had held the opinion that the rate of diffusion of dissolved substances in gels is practically the same as in liquids. However, later investigations in this direction have shown that this behaviour is true only in certain limiting cases, the concentration of the gel exerting a great influence on the rate of diffusion of electrolytes[110, 111]. Further, substances of high molecular weight have been found to diffuse very slowly in gels while for colloidally dispersed substances the gels serve as filters which allow only the dispersion medium to pass through.

Recently, Friedman and co-workers[112] have studied the diffusion of several non-electrolytes in gels of gelatin, agar-agar and cellulose acetate in benzyl alcohol, by a new technique which has several advantages over those employed previously. In this method a gel is covered with an equal depth of water which is kept stirred continuously and the diffusing substance is contained either in the gel or in the outside water. Small samples of water are taken out periodically and analyzed by means of the Immersion Refractometer. Increase in the concentration of the gel has been found to decrease the rate of diffusion markedly; the decrease is linearly related to the increase in concentration in the case of agar gels. The diffusion coefficients have been calculated from an expression developed by Weaver[113] and their values in water and in gels are related by the equation,

$$K_{H_2O}=K_{gel}\left(1+\frac{2{\cdot}4r}{R}\right)(1+\alpha)(1+\pi)$$

in which r is the radius of the diffusing molecule, R the radius of the pores of capillaries in the gel, α the correction factor for viscosity and π the correction factor for mechanical blocking. Patrick and Allan[114] have studied the diffusion of various

electrolytes through silicic acid gels and have found that their results are not in agreement with Nernst's theory of diffusion but can be satisfactorily explained on a theory developed on the basis of electro-kinetic potential.

It has been found that a number of reactions and crystallizations which will not otherwise take place, proceed fairly smoothly in the gel media. In silica gels, cupric ions are reduced to cuprous state and even to metallic copper when treated with glucose [115] and basic lead acetate is reduced to metallic lead by tin [116]. The crystals of mercuric iodide and bromide are obtained in elongated tetragonal form when the silica gel containing potassium iodide is flooded with mercuric chloride [117].

A remarkable phenomenon is, however, noticed in certain cases in which the precipitate formed by a chemical reaction in gel media is deposited in a number of separate bonds or layers or rings. The rhythmic or banded precipitation, first observed by Liesegang and known after him, is observed in Nature in systems of very different origin, namely, in rocks, vegetable matter, plants and animals. In chemical reactions which give rise to such a precipitation it is necessary to use proper concentrations of the reactants and suitably adjust the hydrogen-ion concentration of the system. Mitra [118] has recently shown that periodic precipitates are also formed in the absence of a foreign gel during the coagulation of sols of ferric phosphate, ferric arsenate and ferric borate under suitable conditions.

Several attempts have been made to obtain a mathematical expression relating the distances between the different bands and the several factors involved in their formation. Empirical relations have been obtained by Lakhani and Mathur [119] between the distances of rings of the same ordinal number and the concentration of the diffusing substance, by Mikhalev, Nikijorov and Shemyakin [120] between the distance of the rings and the actual spreading velocity, by Suzanne Veil [121] between the order number of the principal rings and their distances. A theory based on the diffusion law has been recently derived by Hughes [122] and it seems to account satisfactorily for the distances between the several bands.

Various theories have been put forward to account for the origin of the Liesegang phenomenon. The older theories were based on the supersaturation and crystallization of the banded substance and these were followed by theories which aim at explaining the phenomenon from the colloid-chemical point of view. According to these theories, the main rôle is played by the adsorption by the precipitate either of the substance present in the gel or of the sol of the precipitated substance.

On the other hand, some workers have suggested that the Liesegang phenomenon should be explained on the consideration of de Broglie waves associated with the movement of the precipitating agent. Christiansen and Wulff [123] have shown that

the velocity calculated from de Broglie's equation is in good agreement with the experimental value for several precipitates. They have also applied the Schrödinger equation to these systems and have developed a theory which seems to account for the observed phenomenon. Raman and Subbaramaiah [124] have also observed a phenomenon with Liesegang precipitates of silver chloride and silver chromate in gelatin, and they consider this to be unmistakably in the nature of interference effects.

Theories of Gel-formation and Gel Structure

The above-mentioned and several other investigations of the various properties of a number of gels have given birth to many theories of the structure of gels, but most of them are mere modifications introduced in the general theories, to suit the behaviour of particular gels. Three general theories of gel structure have been recognized and these are: (1) solid solution theory, (2) liquid-liquid theory, and (3) liquid-solid theory. None of these explains satisfactorily the phenomena observed during the process of setting and the properties of all classes of gels when set.

The methods of preparation of gels indicate that the first condition or stage for the formation of gels is that the gelling substance should be obtained in the sol condition; this state may only be a temporary one in some cases. This can take place either by mechanical action and ion adsorption from a medium which does not exert any appreciable solvent action. The density of electrical charge on colloidal particles formed from ionic solutions may be positive or negative but it should not be high as otherwise discrete flakes which may be gelatinous would be formed. The condition of low density of charge is probably realized in systems in which the gelling substance is formed as the result of chemical reaction. If, however, this condition does not exist, it is created in some cases by the addition of electrolytes and in other cases by prolonged dialysis. The condition of prolonging the dialysis is essential, for Desai and co-workers [125] have shown in a series of papers that the density of charge on colloidal particles, determined from the cataphoretic velocity, increases during the earlier period of dialysis and subsequently decreases.

Another important condition for the formation of a gel is to obtain a sufficient amount of the gelling substance in a supersaturated state. The importance of this condition can be realized from the fact that under given conditions certain concentration limits are prescribed for every gel. If these are exceeded, no gel-formation takes place. Von Weimarn [126] has expressed the results of his investigation on the effects of concentration in the form of an equation which leads to the inference that gel-formation takes place only when the factors involving

viscosity and the degree of supersaturation are large and the solubility of gelling substance is small.

The second condition of gelation consists in the coalescence or coagulation of the particles of the sol of the gel-forming substance at a velocity which is not too great [127]. It has been shown by Hurd, Raymond and Miller [42] that the setting time of a particular mixture giving rise to silicic acid gel from a positively charged sol, is decreased to a greater extent by the addition of sodium chloride than in the presence of the same quantity of sodium sulphate. This observation must raise doubts regarding the nature of coagulation involved in the process of the formation of inorganic gels. But the study of the viscosity and opacity changes during the coagulation and gelation of a concentrated sol of stannic hydroxide under not widely different conditions has yielded results which are similar in nature. De Jong [128] has also concluded that gelation of agar sol has all the characteristics of flocculations. These observations together with the fact that same methods are employed for the study of kinetics of coagulation and gelation lead one to conclude that the agglomeration of colloidal particles in inorganic gels takes place by a mechanism which is analogous, if not identical, with true coagulation.

The process of the formation of large entities is accompanied by very strong absorption of the surrounding medium so that the ultimate particles of the gel are so heavily solvated that hundreds of molecules of the medium are associated with one molecule of the gel-forming substance. These conclusions have been confirmed from the calculations made from Hatschek's formula for the determination of the degree of hydration.

The third stage consists in the formation of specific structures which are fairly complicated. During this process the complete immobilization of the fluid takes place which, according to Ostwald, is the most important characteristic of a gel. It is probably at this stage that rapid changes in the viscosity and surface tension of the gel-forming system take place. Nothing definite is known regarding the forces which bind the ultimate particles of the gel together; it has only been surmised that they are of the same nature as residual affinities since they can be overcome in the same manner as in melting.

The above discussion reveals that gels are made up mainly of two phases. Ostwald pictured that these two phases are liquids and on this basis put forward the emulsion theory of gel structure. On critical examination Hatschek has shown that this theory is faulty since the mechanical properties of a liquid-liquid system do not correspond to those of true gels.

The other two theories assume that a gel is made up of solid and liquid phases. The ultra-microscopic observations and the method of Tyndall Effect have indicated that the solid or the semi-solid phase is present but it exists in such a fine grained

structure that it is not visible by these methods. The solid solution theory only states that the dispersion medium is held in the gel in the form of a solution in the solid colloid and does not deal further with the structure of gels. The liquid-solid theory considers that the structure of gels may be (i) cellular, or (ii) fibrillar or micellar.

According to the first theory the structure of gels is made up of cells built of the solid phase, and these hang together at certain points so as to form a network. The liquid phase of the gel is held in the form of droplets in this cellular frame work. The cellular structure has been actually observed in the case of some gels (Bütschli, silicic acid) and the microscopic observation of Hardy [28] also lead to the conclusion that gelatin gels form a framework which is an open structure and which holds the fluid phase in its interstices. This theory accounts for the elasticity of gels but cannot provide satisfactory explanation for the phenomena of syneresis, swelling and dehydration and the absence of any change in the electrical conductivity during setting [129].

The fibrillar theory was first put forward by Nägeli [130]. It postulates that gels are made up of fibrous structure formed of the solvated solid phase and the liquid phase is contained in the pores of these fibres or aggregates, both phases being continuous. Several views are held regarding the mechanism which gives rise to the fibrils. They may be either formed by the mechanical agglomeration (following coagulation in the case of inorganic gels) of the colloid or may consist of very large polymerized molecules or the fine crystals of the gel-forming substance.

In the case of the gelatin gels the sol, according to Bogue [131], already contains slightly hydrated molecules united into short threads. On cooling the sol, these threads increase in length, swell, lose freedom of motion and cohere with each other. Miss Laing and McBain [2] also consider that during gelation the particles of soap sols stick together in filamentous structure. Barrat [132] has summed up the conclusions regarding the structure of elastic gels in a statement that they are made up of a network of a mass of intersecting fibrils which are at first microscopic and later become ultra-microscopic.

In the case of silicic acid gel the simple molecules which are first formed [133] change over to complex molecules (β-silicic acid) probably by condensation accompanied by the splitting of water, and the threads are made up of polysilicic acid molecules. Hurd [134] has suggested that theoretically the process of condensation should occur more readily if an equal number of the simple molecules of silicic acid ionize, giving rise to positive and negative ions [$Si(OH)_3^+$ and $SiO(OH)_3^-$] and if the collision between them occurs more frequently. The probability of this mechanism is supported by the amphoteric character of silicic acid. The polysilicic acid molecular chains which are inter-

connected in the three dimensions in the gel, are neither large nor are they of sufficient density and hence are not visible in the microscope. This process of the formation of the fibrils explains the absence of a change in the electrical resistance of the silicic acid gel during setting and the non-thixotropic behaviour of these gels.

It has often been suggested that the solid phase in a gel is crystalline and the phenomenon of gelation is similar to crystallization. Krejci and Ott [135] have found a cristobalite pattern by an X-ray analysis of the freshly prepared gels of silicic acid. But there are several gels in which there is no evidence in favour of the existence of crystalline structure, although a tendency towards such a structure is probably indicated. Hardy [136] concludes, 'The process of gelation has many points of resemblance to crystallization but the masses which have all the appearance of crystals are not crystals'.

The lenticular form of bubbles generated during gelation indicate that there exists a force in gels which tends to orientate the threads. In this process they cause further contraction and thereby affect the squeezing out of the fluid through the capillaries. This is manifested as syneresis. During the dehydration of gels also the fluid is removed through the capillaries which shrink in size and get filled up with air in well-dried gels. Syneresis and dehydration seem to be related to each other, probably on account of the nature of capillaries, as both of them have been found to be minimum in the case of silicic acid gels near the neutral point. When the dried silicic acid gels are moistened with water, the swelling of the outer walls of the gels causes a strain which makes the gels crumble violently into pieces. This phenomenon was first observed by Bhatnagar and Mathur and is described by Ostwald in *Kolloid Zeitschrift* as Bhatnagar-Mathur Effect [137] which has been studied systematically at the Lahore Laboratories.

Diffusion through gels also takes place through the fluid which fills these capillaries. They are wide in dilute gels and hence the rate of diffusion in them is the same as in the free dispersion medium. But the increase in the concentration of the gel narrows down the capillaries and hence diminishes the amount of the fluid in them and thereby decreases the quantity of the substance diffusing in.

The size of the pores determined from the dehydration data in the case of variously dried silica gels has been found to vary between $2{\cdot}75\mu\mu$ and $1{\cdot}376\mu\mu$ between the two opacity points. Friedman and co-workers found from the diffusion data that the radii of the pores in different gels vary from $1m\mu$ to $5m\mu$. These data confirm Pauli's suggestion that the gels are ultra-porous. The average value of the interval between two threads has been found by Kraemer [138] to be of the order of 100 millimicrons.

Subba Rao[105] has put forward a concept that the capillaries in the porous gels are in the form of cavities with constricted ends. This concept offers not only a satisfactory explanation for the existence of the hysteresis loop but also explains the phenomena of the scanning and the drift of the loop. The disappearance of the loop on progressive sorption and desorption in elastic gels, such as those of rice and dhal, is explained on the consideration that the cavities swell on the imbibition of water, become elastic and hence lose their power of entrapping water.

The length and number of the fibrils in a gel are responsible for its elasticity. Poole[55] has developed a mathematical theory for the behaviour, under stress, of a structure composed of a mesh of cylindrical threads and found that the experimental elasticity-temperature-concentration relations for gelatin and cellulose acetate gels are in qualitative and approximately quantitative agreement with the theory. The time factor or 'creep' is mainly due to the reversible flow of the liquid phase in the interstices of the solid phase.

The fluid contained in gels is probably a solution of the gel-forming substance in the dispersion medium. Some of it is associated with the micelles and the rest is contained in the interstices of the fibrils. These have been considered as 'fixed' and 'free' fluids[139]. It is the free or interstitial fluid which comes off first during desorption of gels. The rigidity of gels has been shown to depend upon the relative amounts of the free and fixed fluid contained in them.

Freundlich, Ostwald, Hauser and Kistler[140] consider that in thixotropic gels the water molecules are orientated and form thick rigid envelopes round the particles of the gel. These lyospheres are destroyed by shaking and reformed on allowing the gel to stand. But Russel and Rideal[141] have collected evidence in favour of the view that the ultimate particles of the thixotropic gel-forming material are anisotropic or anisometric or both and the charge and the adsorbed water molecules are unequally distributed. According to them the structure of thixotropic gels is made up of these entities which are regularly orientated and the mechanical stress only destroys this orientation.

The anisometric nature of the micelles has been indicated in sols of cellulose derivatives by X-ray methods. Subba Ramaiah[77] has also found from his optical method that the micelles in the rapidly setting silicic acid gels possess a spherical asymmetry and the spherical symmetry of the micelles in the slow setting systems decreases due to an orientation subsequent to the setting. Freundlich also states that it is undeniable that the particles in many thixotropic systems are non-spherical.

It would appear from this survey that the fibrillar theory is in harmony with most of the characteristic properties and varied

phenomena shown by gels. It explains satisfactorily the elasticity, viscosity, syneresis, swelling, dehydration and hysteresis, diffusion and optical and ultra-microscopic phenomena. This theory has the adherence of most of the workers on the subject of gels, although it cannot be assumed *prima facie* that all gels have the same architecture.

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SECTION OF GEOLOGY

President :—M. R. Sahni, M.A., Ph.D., D.Sc., D.I.C., F.A.Sc.

Presidential Address

(*Delivered on Jan. 3, 1941*)

PALAEOGEOGRAPHICAL REVOLUTIONS IN THE INDO-BURMESE REGION AND NEIGHBOURING LANDS.

(VINDHYAN TO DEVONIAN)

INTRODUCTION.

I deeply appreciate the honour you have done me in electing me to preside at the Geology Section of the Indian Science Congress.

We meet to-day at a critical juncture in the world's history: under the shadow of a great war and at a period of strife and restlessness. It is therefore, perhaps, in the fitness of things that I should select the title Palaeogeographical Revolutions as the subject of my address. Such far-reaching changes are not merely the heritage of social or political systems, but are also inherent in our geological systems, in our great continents and the restless oceans.

THE CHANGING FACE OF THE EARTH.

The earth pulsates with life. The once lofty snow clad mountain ranges, like the Vindhyans, have been levelled and humbled by the impact of weathering agents. The Poles have wandered far and wide through geological ages and there is reason to believe that during the early Gondwana period the South pole was situated in the middle of the Indian Ocean, while the North pole lay near Tulterango Mexico.[1] On the contrary the great ice-bound polar regions supported a warm water coral fauna during the Palaeozoic and a warm sun blazoned upon a luxuriant tropical vegetation during the Mesozoic era. This is not all. Even the great continents having played their part in the earth's equilibrium founder and disintegrate, the seas become

[1] Koken, E. Indisches Perm und die Permische Eiszeit. *Neues Jharb. für. Mineral.* Festband, pp. 446–546, 1907.

sedimented by the passage of time: the face of the earth changes. The result of these phenomena is a redistribution of land and sea, of plant and animal life leading, in short, to Geological and Geographical revolutions. It is about these changes that I propose to speak to-day.

THE BASIS OF PALAEOGEOGRAPHIC RESTORATION.

Before considering the Vindhyan landscape, with which I propose to commence, let us for a while examine the basis upon which the restorations of ancient geographies are founded. The only basis of exact correlation is the occurrence of identical species of animal or plant fossils in strata of marine or continental origin as the case may be. Our conclusions are true and exact in the measure in which our observations and identifications are accurate. So much so that when data are reliable it is possible to institute exact correlations in strata separated by hundreds and even thousands of miles, and we are enabled then to determine the extent of inter-marine communications. Few more remarkable instances of this type could be cited than that of the Middle Devonian (Eifelian) faunas of the Shan States and Germany which, though separated by several thousand miles, are specifically identical and are a clear indication of a free marine connection between Southern Asia and Northern Europe.[1]

But the task is not quite so simple and many difficulties beset the investigator in this field. There are many anomalies which are difficult to explain. The reason perhaps is that the most obvious explanations are not always the most reliable. For example, whenever the marine faunas in two regions, even in close juxtaposition, are unaffined, our first instinct is to interpolate a land barrier, as we have done in the case of the Cretaceous Seas of Central and Western India (Bagh Sea) on the one hand and Southern India (Trichinopoly Sea) on the other. Referring to the accepted contrast between the Bagh and Trichinopoly Cretaceous beds Wadia [2] observes that they differ

> 'As widely as it is possible for two formations of the same age to differ'

and that this contrast

> 'Denotes isolation of the two seas in which they were deposited by an intervening land barrier of great width, which prevented the inter-sea migrations of the animals inhabiting the two seas'.

Recent identifications of certain Bagh fossils, however, tend to show that this land barrier was probably not so effective and must have broken down during periods of marine trans-

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[1] La Touche, T. H. D. Geology of the Northern Shan States, *Mem. Geol. Surv. Ind.*, Vol. XXXIX, Pt. II, p. 239, 1913.

[2] Wadia, D. N. Geology of India, p. 207, 1939.

gression for among the Bagh fauna occur *Protocardium pondicherriense* D'Orb., *Cardium (Trachycardium) incomptum* Sow., *Macrocallista sculpturata* (Stoliczka) and *Turritella (Zaria) multistriata*, which are characteristic of the Upper Cretaceous of Southern India. A Nautilus—*N. labechei* D'Archiac et Haime—from the *Cardita beaumonti* beds of Sind appears, according to Blanford,[1] 'Indistinguishable from *N. bouchardianus* found in the upper Cretaceous Arialur beds of Pondicherry'. Our idea of the Cretaceous palaeogeography of India therefore needs modification, though perhaps only in detail.

Differences between the faunas (or floras) of two regions need not necessarily indicate a land (or sea) barrier. Variation in the physical conditions such as temperature, depth, relative salinity, direction or strength of ocean currents of intercommunicating marine regions may be just as effective barriers to the migration of marine faunas as land barriers. But our knowledge has not yet reached a stage when the effects of these are readily traceable in fossil faunas, though the occurrence of ancient coral reefs indicating known conditions of depth and temperature, of stunted marine faunas often indicating excess of salinity, of the presence of boreal elements (modern representatives of which inhabit the cold waters) of xerophytic plant types like the Lower Cretaceous species *Weichselia reticulata*[2] indicating proximity of arid conditions, are often instructive and interesting. Similarly differences in the relative heights of neighbouring regions may effectively bar the intermingling of floras and if these differences are considerable, as in the case of high mountain ranges, sharply defined floral zones may result without the interpolation of actual physical barriers.

In a certain measure the immediate environment must always leave a marked local impress upon faunas and floras, but certain widespread or cosmopolitan types sometimes weave a thread of uniformity through the otherwise differing life-provinces, though these may be suggestive only of remote connections. It is the more characteristic and vertically confined types that are the more useful for palaeogeographic restoration. Thus the Lower Devonian fauna (Hercynian facies) characterized by *Tentaculites elegans*,[3] the Middle Devonian fauna characterized by *Calceola sandalina* and its associates, the Upper Devonian fauna with *Spirifer verneuili* give us clues to the intercommunication of the seas during these times. The genera

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[1] Blanford, W. T. Geology of Western Sind. *Mem. Geol. Surv. Ind.*, Vol. XVII, Pt. I, p. 36, 1878.

[2] Sahni, B. The occurrence of *Matonidium* and *Weichselia* in India. *Rec. Geol. Surv. Ind.*, Vol. 71, Pt. 2, p. 156, 1936. See also Gothan, W. *Jahrb. Preuss Geol. Landesanst*, 43, pp. 772–777, 1921.

[3] The question of the age of this Hercynian fauna in the Shan States will be discussed in detail later.

Glossopteris and *Gigantopteris*[1] both widespread forms give the extent of the continents during Permian times. Particular importance therefore attaches to forms that are widespread yet confined to certain regions and horizons.

There is another very important factor which has probably been overlooked much oftener than we realize. I incline to the view that the supposed effective barriers which have been presaged in some cases where faunal differences are manifest are probably hypothetical. *Such differences may be due to the fact that we are not dealing with strictly contemporaneous faunas, but with faunas of varying ages within the same geological system.* We may even be dealing with faunas that are insufficiently known or indifferently preserved so that the extent of affinities with other faunas may be exaggerated or minimized because of incomplete determination.

Thus it is often stated that while the Ordovician fauna of the Northern Shan States bears a striking relationship to the North European fauna, the Himalayan fauna appears to be affined to the American Ordovician fauna and therefore it is argued that an effective barrier separated these regions. But in my opinion this explanation is unsatisfactory, and the differences between the poorly preserved Himalayan faunas and the Shan Ordovician faunas are probably due to lack of absolute contemporaneity rather than to imaginary barriers. However, this problem will be further considered later under the Ordovician section. Likewise the greater affinity of the Cambrian faunas of Iran with the far Indo-Chinese rather than

[1] The *Gigantopteris* and *Glossopteris* floras although now in close juxtaposition are quite distinctive. It has been claimed that their present position is the result of drifting towards each other of the continents supporting these floras (Wegner's hypothesis of continental drifts). This explanation however does not seem altogether satisfactory, for if the sea separating them was a narrow one then a fair intermixture would be inevitable, which is not the case. If, on the other hand, a wide geosyncline separated the continents then their drift towards each other would lead to puckering up of the geosynclinal sediments and a mountain range would result. The Eastern Assam and Arakan regions would at first sight appear to supply the requisite mountain range. But surprisingly enough the Eastern Assam and Arakan ranges which practically form the boundary between the *Glossopteris* and *Gigantopteris* floras do not contain any Permian or pre-Permian marine sediments; at least such are not exposed on the surface and we may perhaps conclude that there was no wide marine barrier between these palaeobotanical life-provinces. A more satisfactory hypothesis therefore appears to be that these floras lay in different contiguous climatic zones, which explains both the juxtaposition and distinctiveness of these floras. The palaeobotanical data, according to my brother Prof. B. Sahni, clearly indicate that the climatic differences between the two provinces are well marked, that the *Gigantopteris* flora is a warm climate flora and that the *Glossopteris* flora is a temperate flora, starting originally as a cold temperate flora. (See B. Sahni, *Journ. Ind. Bot. Soc.*, Vol. XV, No. 5, pp. 322-323, 1936, and E. Norin, Geol. Foren Stockholm Forh Bd. 46, Heft. 1-2, 1924.)

with those of the Salt Range which lay in the same pathway of migration, is in our opinion due not to any impassable land barrier but to difference in the relative ages of the Cambrian faunas of the first and last named regions.

Sudden bursts of migration and the apparent mingling of faunas of different ages often present baffling problems. One cannot cite a more striking instance than that of the Zebingyi fauna of the Shan States,[1] in which are co-mingled species of *Monograptus*, so typical of the Silurian, and *Tentaculites elegans*, equally characteristic of the Hercynian (Lower Devonian) facies of Southern Europe. The question then faces us, what is the age of the Zebingyi beds—Silurian or Devonian? for upon our reply will depend our conception of the distribution of seas during those periods. I shall endeavour to answer this question later.

Often there is wide divergence of opinion in the interpretation of evidence which may affect problems of palaeogeographic restoration. Thus the Namyau strata of the Shan States are relegated to the Trias by Frommaget [2] and others working in Indo-China, while I consider their Jurassic age unimpeachable.[3]

Of recent discoveries in Burma which affect the problem in hand reference must be made to the important find by Clegg [4] of certain foraminiferal sediments in the Second Defile of the Irrawaddy river. The Cretaceous [5] age of these sediments was proved by my identification of the genus *Orbitolina*. Apparently a single species, *Orbitolina birmanica* Sahni, is represented.[6] Reference may also be made to recent finds, during my surveys of the Shan States, of ammonite bearing Lower Triassic strata [7] (Na Hkyam beds) in the Northern Shan States as well as of Middle Devonian rocks [8] (Meso beds) in the Southern Shan States. The Na Hkyam beds constitute the only known record of the Lower Trias in Burma, while no other Middle Devonian rocks are known from the Southern Shan States.

But since some at least of these discoveries refer to the Mesozoic, we are not directly concerned with them here.

We may now revert to a consideration of the Vindhyan.

[1] La Touche, T. H. D. *Loc. cit.*, pp. 163–170, 1913

[2] Frommaget, T. *Bull Sérv. Géol. Indochine*, Vol. XVIII, Fasc. [illegible], pp. 19-20, 30, 1929.

[3] Sahni, M. R. *Rec. Geol. Surv. Ind.*, Vol. 71, Pt. 2, pp. [illegible]-230.

[4] Clegg, E. L. G. *Rec. Geol. Surv. Ind.*, Vol. 72, pt. 4, 19[illegible]

[5] Sahni, M. R. *Rec. Geol. Surv. Ind.*, Vol. 71.

[6] I provisionally assigned the topmost Barremian age to this species on account of its close relationship with *Orbitolina tibetica* Cotter. Further comparisons appear to indicate much similarity with *O. scutum* v. Fritsch and *O. trochus* v. Fritsch, of the Cenomanian. The possibility of the Burma orbitolines being Cenomanian cannot therefore be entirely overlooked.

[7] Sahni, M. R. *Proc. Twenty-fifth Indian Science Congress*, Part III, p. 114, 1938.

[8] *Ibid.*, pp. 114-115, 1938.

VINDHYAN PANORAMA.

It would perhaps be futile in the present stage of our knowledge to discuss the conditions of deposition of the pre-Vindhyan strata, for here we are much within the domain of speculation. I propose therefore to commence with the probable distribution of land and sea in Southern Asia during the Vindhyan period which coincides with the first flush of life on the earth, over 500 million years ago. Here too, I am afraid, we are on no certain ground, for we catch but stray glimpses of this ancient panorama, and the effort at restoration is like that of a painter endeavouring to restore a terribly mutilated old master. Still a clue here and there may be deciphered, or ancient landmarks, unmasked by the removal of the overlying mantle of rocks, fitted together like a jigsaw puzzle in restoring ancient geographies.

DISTRIBUTION, CORRELATION AND CONDITIONS OF DEPOSITION OF VINDHYAN SEDIMENTS.

The belt of Vindhyan sediments constitutes the highlands of Central India and extends from the Vindhyachal mountains in the west to Behar in the east. North of this belt extends the vast Indo-Gangetic plain—a trough of geologically recent origin, now filled up by masses of alluvium brought down by the Indo-Gangetic drainage system. The Deccan plateau forms the southern limit of these sediments.

Lithologically the Vindhyans of Central India are characterized by the development of highly coloured sandstones with a prevailing red or purple colour, by intercalations of gypsum indicating in general conditions of aridity or semi-aridity. Limestones occur in the lower part of the succession clearly indicating marine conditions.

It is a remarkable circumstance that the Cambrian strata of the Salt Range contain, in the lower part of the sequence, beds which betray a striking lithological similarity to those of the Vindhyans of Central India. There can be little doubt that these strata were deposited under identical conditions except that aridity was perhaps more marked in the Salt Range region than in the Vindhyan.[1]

The recent discoveries of Cambrian strata in Iran (Hormuz Series) and their striking lithological similarity with those of the Salt Range is likewise strongly suggestive of the extension of similar arid conditions westwards. Fox[2] lays stress upon this view when in reference to the Salt Range he says

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[1] Auden refers to the problems of Vindhyan climates and correlation (with the Cambrians) in a brief abstract (*Internat. XVII Geol. Congress, Abstracts*, p. 216, 1937). The full paper of which I had the privilege of seeing the MS. will, it is hoped, be published shortly.

[2] Fox, C. S. Progress Report for 1928.

'I would definitely connect these Vindhyan strata with those of the Punjab Salt Range. My experience in this region is in agreement with such a connection. The beds of the Salt Range, i.e. the Cambrian strata from the Salt pseudomorph beds down to the purple sandstone, and in my opinion, the saline series below, represent deposits of an arid region in a shallow sea. The same is in general true of the upper Vindhyans'.

In an interesting and important paper published in 1928, Fox expressed himself even more emphatically when in reference to the Salt Range Cambrian succession he said [1]

'All the deposits in this succession are suggestive of marine deposits in hot desert regions and thus have geographical relationship'.

Auden [2] from his experience of Vindhyan sedimentation in the Son Valley concurs in this view. And I think there can be no question about the occurrence of identical physical conditions in these regions during the periods named. But the crucial point we have to decide at the moment is, are the Iranian Hormuz Series, the Salt Range Cambrians and the Vindhyan strata contemporaneous?

Now the only basis of exact correlation is the presence of identical species of animal or plant fossils. In the Vindhyans of Central India the only fossil remains are circular, possibly (originally) lens shaped discs found by Jones [3] in 1908, in some black shales near Neemuch. These organic remains have created a storm of controversy. Jones himself thought them to represent *Obolella* or *Chuaria circularis*, described by Walcott from the pre-Cambrian rocks of Arizona or possibly the operculum of *Hyolithellus*. Walcott and Resser [4] of the Smithsonian Institution, Washington, regard them as primitive brachiopods related to *Acrothele*. Chapman [5] who made a detailed study of these fossils thinks they are 'possibly Atrematous and Neotrematous brachiopods' of early Cambrian or pre-Cambrian age, and created the genera *Fermoria* and *Protobolella* for their reception. Howell [6] however casts doubts on these views and is more in favour of their plant origin. I re-examined [7] Chapman's types and other material and came to the conclusion that these fossils did not possess any characters which recalled primitive

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[1] Fox, C. S. A contribution to the Geology of the Punjab Salt Range. *Rec. Geol. Surv. Ind.*, Vol. LXI, Pt. 3, p. 173, 1929.

[2] Auden, J. B. Vindhyan Sedimentation in the Son Valley. *Mem. Geol. Surv. Ind.*, Vol. LXII, Pt. 2, p. 223, 1933.

[3] Jones, H. C. *Rec. Geol. Surv. Ind.*, Vol. XXXVIII, p. 66, 1909.

[4] General Report. *Rec. Geol. Surv. Ind.*, Vol. LX, p. 18, 1927.

[5] Chapman, F. *Rec. Geol. Surv. Ind.*, Vol. LXIX, Pt. I, pp. 109-120, 1935.

[6] General Report. *Rec. Geol. Surv. Ind.*, Vol. LXI, pp. 21-22, 1929.

[7] Sahni, M. R. *Rec. Geol. Surv. Ind.*, Vol. LXIX, Pt. 4, pp. 458-468, 1935.

brachiopods. I considered their affinities uncertain and therefore proposed the family *Fermoriidae* for them: one specimen—the only one which looked like one of the *Atremata*—was renamed *Vindhyanella.*

Dr. Howell in a personal communication to me has expressed accord with my views and considers the Vindhyan forms related to some similar remains discovered in the United States, in rocks of ?pre-Cambrian age. Although indefinite comparisons have been suggested with early Cambrian forms none of these organic remains from the Vindhyans are related to the fossils from the known fossil horizon in the Cambrian of the Salt Range or Iran. In the absence of fossil evidence it is impossible to suggest any precise correlation of the Vindhyans of Central India with the Salt Range Cambrian succession or the Hormuz Series of Iran. There is indeed no consensus of opinion whether the Cambrian strata in the Salt Range are of Lower or Middle Cambrian age, though evidence is now veering towards the latter view. And the supposed Lower Cambrian age of the Iranian (Hormuz) strata is now definitely proved to be Middle and Upper Cambrian. It would appear that the correlation of the Vindhyans with the Salt Range and Hormuz Series was tempted by the supposed Lower Cambrian age of these strata and their marked lithological similarity supported possibly in some measure by the supposed primitive brachiopod affinities of the Vindhyan fossils. But since the only known Vindhyan fossils have been shown not to be brachiopods of Lower Cambrian affinities or not even brachiopods at all, I think a correlation between the Vindhyan and Cambrian strata seems unjustifiable though one may certainly concede that the physical conditions remained unchanged from the Vindhyan to Cambrian times. Moreover, since the Vindhyans are so little metamorphosed, the absence of other fossils such as tribolites or pteropods seems difficult to explain, especially when the conditions of deposition were identical, at least in part. It is in my opinion unlikely that if the Vindhyan, the Salt Range and Iranian strata belonged to the same province of sedimentation, the one would be so bereft of life while the others teemed with it.

SOUTHERN AND EASTERN ASIA.

Let us now examine the conditions prevalent further east, in the central and eastern Himalaya, in Burma and China.

Our ideas concerning the Vindhyans of the Himalayan region have undergone much change since Vredenburg[1] suggested that

> 'amongst the mountains of Northern India, the Vindhyans are represented by the Deoban Series near Chakrata, the Krol Series and

[1] Vredenburg, E. W. Geology of India, p. 34, 1910.

Infra-Krol of the Simla area, the Haimanta of the Northern Himalaya, the Attock Series of the Punjab, and a portion of the Panjal System in Kashmir.

'Of these extra peninsular occurrences, the Attock Series corresponds more particularly with the Lower Vindhyan, the Krol Series more particularly with the Upper Vindhyans. The Haimanta probably includes both.'

The fossil fragments of the genus ? *Chonetes* found, according to Das-Gupta and Vredenburg,[1] in the Krols near Solon (Simla Hills) appear to indicate that they are much younger than Vindhyan strata and are probably of about Permian age. Auden[2] disagrees with this identification completely (as did Hayden earlier) and even suggests that the supposed *Chonetes* from the supposed Krols is in fact an Oyster from the Subbathu series! I have not seen this *Chonetes* and am therefore unable to express an independent opinion on this identification, but in regard to the field relations of the beds under consideration, I am sure, my colleague's observations can be entirely relied upon. However, the main fact from my viewpoint is that at all events the Krols are post-Vindhyan, a view already expressed by Pilgrim and West[3] in 1928.

We are then left with the unfossiliferous sediments variously grouped under the names Baxa, Jaunsar, Attock and Simla slates. Are these to be correlated with the youngest of the Purana sediments, namely, the Vindhyans? Are they even to be correlated amongst themselves? There is at present no satisfactory reply to these queries, but their correlation with some part of the Vindhyans appears at least a plausible, even though speculative hypothesis. If we accept this correlation we may visualize the extension of a northern Vindhyan sea over certain parts of the lesser Himalayas. This sea probably did not extend much further north, for Tibet was then probably a land area. In this connection it may be mentioned that the age of the Ralam series doubtfully assigned by Heim and Gansser[4] to the basal Cambrian is not precisely known and therefore no correlation with the above-named formations can be suggested at this stage.

We may now consider the correlation of the lower part of the Haimanta system with the Vindhyans. This system includes:—

Fossiliferous slates with *Olenus*	1,000 ft. thick.
Slates and quartzites without fossils	300–400 ft. thick.

[1] Das-Gupta, H. C. and Vredenburg, E. W. *Jour. As. Soc. Bengal*, N.S. Vol. XIV, p. clxxxv, 1918.

[2] Auden, J. B. *Rec. Geol. Surv. Ind.*, Vol. LXV, p. 536, 1932.

[3] Pilgrim, G. and West, W. D. *Mem. Geol. Surv. Ind.*, Vol. LIII, p. 3, 1928.

[4] Heim, A. and Gansser, A. Central Himalaya. Geological Observations of the Swiss Expedition. *Denkschr. Schweiz. Naturforsch. Gesellsch.*, Bd. LXXIII, Abh. I, p. 202, 1936.

The Upper division can be correlated with the *Olenus* zone of the European or American Cambrian and the correlation of the Lower division with the upper part of the Puranas, i.e. the Vindhyans seems most likely. However Burrard, Hayden [1] and Heron observe that

> 'the relations of the Haimantas to the Purana rocks of the Himalayan zone have not yet been worked out and it is not known definitely whether there is a gradual and conformable passage from the one into the other or whether the lower beds of the Haimantas are contemporaneous with the upper strata of the Puranas nor is it possible to say at what period the Himalayan zone of the Puranas first became a land-surface'.

The correlation above suggested, however, appears to possess an air of justifiable speculation. But if admissible the absence of limestones in the Haimantas which are composed mostly of detrital deposits and

> 'the absence of any post-Purana beds among the rocks of the Himalayan zone suggests that the present southern boundary of the Haimanta deposits marks approximately an original limit of deposition and consequently the southern shore of the sea in which the Haimantas were laid down' [2].

the southern shore in fact of the northern Vindhyan sea.

The correlation of the Shillong series of Assam, the Chaung Magyi series of Burma and the Sinian series of China with some part of the Purana system has sometimes been suggested. According to Grabau [3] the Vindhyan strata are undoubtedly referable to the Sinian system. Grabau further considers the Vindhyan system to be entirely of continental origin, which we now know is certainly not the case and I am of opinion that his reference of the whole of the Sinian system to continental deposits will probably be negatived by further evidence. We further know that limestones occur in the Chaung Magyi series in certain parts of the Shan States mapped by Hobson, [4] though no limestones were noticed in the area mapped earlier by La Touche [5] and later by myself. [6] The vast thickness of the Chaung Magyis is probably of marine origin and their correlation with the upper part of the Purana system, i.e., with the Vindhyans instead of with the still older Dharwars as advocated by Holland

[1] Burrard, S., Hayden, H. H. and Heron, A. M. A sketch of the geology and geography of the Himalaya mountains and Tibet. Pt. IV, p. 335, 1934.

[2] *Ibid.*, pp. 334-335. 1934.

[3] Grabau, A. W. Stratigraphy of China, Palaeozoic supplement, p. 423, 1923-24.

[4] Hobson, G. V. General Report for 1928.

[5] La Touche, T. H. D. *Mem. Geol. Surv. Ind.*, Vol. XXXIX, p. 47, 1913.

[6] Sahni, M. R. General Reports for 1929–1933.

or with the Cuddapahs as suggested by La Touche, seems plausible.

The extension of Sinian strata into Manchuria via the provinces of Shensi and Shantung indicates the eastward extent of the Vindhyan sea. The presence of the Nankou tillite in China shows that while glacial conditions prevailed for a time near the eastern end of the Vindhyan geosyncline, arid conditions held sway far to the west. Locally, however, in the region of Shensi and Honan where red sandstones occur, arid conditions prevailed. The cause of this according to Grabau [1] appears to have been

> 'the height of the bounding ranges of mountains which supplied the sediments and the fact that they intercepted the moisture-bearing winds from the south-east. If this was the case, the belt of easterly winds must have been shifted further northwards at that time, than the position which it now holds'.

We may now attempt to present a more or less connected picture of the Vindhyan panorama. If it is said that much of it is based upon speculative hypothesis, one can only emphasize its inevitability considering the paucity of evidence.

The Vindhyan sediments in the Central Indian region indicate a sea extending from the Vindhyan mountains in the west to as far as Behar in the east and this I propose to call the 'South Vindhyan sea'. The marked overlap of the sediments northwards indicates the approach of land and the Indo-Gangetic alluvial region was probably then a land area. That life had already dawned is shown not only by the presence of such genera as *Fermoria* or *Vindhyanella* but also by the presence of glauconite which, according to various authors is a sure sign of organic existence. During this period arid conditions prevailed.

No rocks which can be correlated with the Vindhyans have been found in Iran and the intervening region as far east as the Salt Range, except the Kalu series of Afghanistan which, according to Hayden [2], recall the Haimantas. One can only suggest the probable occurrence of Vindhyan strata in this area. In this western region then we can only speculate upon the occurrence of marine conditions, but in regard to their continuation eastward along the Himalayan region, through Assam, Burma, the provinces of Shensi, Shantung and Manchuria in China, we are perhaps on a more sure footing, and we may grant the existence of an ancient geosyncline harbouring a northern sea in Vindhyan times. But in the present stage of our knowledge who would attempt to define more precisely

[1] Grabau, A. W. *Loc. cit.*, p. 15, 1923-24.

[2] Hayden, H. H. Geology of Northern Afghanistan. *Mem. Geol. Surv. Ind.*, Vol. XXXIX, Pt. 1, p. 23, 1913.

the boundaries of this northern sea and its probable connections with the South Vindhyan sea of the Central Indian region ?

CAMBRIAN PALAEOGEOGRAPHY.

EXTENSION OF THE CAMBRIAN SEA TO WESTERN ASIA.

Recent work has necessitated far-reaching changes in our conception of the Cambrian palaeogeography of Asia which I would now like to bring to your notice. It was at one time believed that the genus *Redlichia* was confined to eastern Asia and that it did not occur in any other part of the world. It was likewise held that in the Asiatic region, Cambrian strata were confined to eastern and southern Asia. We now know that Cambrian strata as well as the genus *Redlichia* are widely distributed in western Asia having been found at numerous localities in Iran. The statement that 'our ignorance of the existence of any Cambrian beds in Persia (Iran), Asia Minor or north-east Africa prevents any definition of the boundaries of the Pacific province in the region to the west of India'[1] thus needs emendation in important respects. Further evidence might show—indeed there appear to be indications in that direction—that the barrier which is believed to have 'effectually checked the free intermigration of the typical European and Asiatic faunas in this direction (west of India) during Cambrian times' was probably not completely effective, as believed,[2] but permitted slight, very slight, intermingling far in the west.

The extensive occurrence of thick deposits of Middle and Upper Cambrian ages in Iran has been proved within recent years by the geologists of the Anglo-Iranian Oil Company.[3] Fossiliferous Cambrian strata have similarly been recorded from as far west as the shores of the Dead Sea. Indeed this record dates as early as 1910 when Blanckenhorn[4] announced the occurrence of a representative of the genus *Ptychoparia*[5] in that region, but it appears to have been lost sight of. The occurrence of representatives of the Middle Cambrian Hormuz Series on the islands off the pirate coast of Oman and probably also on the Arabian mainland has similarly been proved. These are important discoveries. Of no less significance is the identification of

[1] Reed, F. R. C. *Rec. Geol. Surv. Ind.*, Vol. XL, Pt. 1, p. 15, 1910.

[2] *Ibid.*, p. 15, 1910.

[3] Böckh, H. de, Lees, G. M. and Richardson, F.D.S. Contribution to the Stratigraphy and Tectonics of the Iranian ranges (*in* Gregory, J. W., Structure of Asia, 1929).

[4] Blanckenhorn, M. *Zeitschr. Deutsch. Geol. Gesellsch.*, Bd. LXII, pp. 410–13.

[5] King, W. B. R., remarks that this form which suggests relationship with *Protolenus* may be identical with his *Anomocare campbelli* (*vide Geol. Mag.*, Vol. LX, p. 514, 1923).

Paradoxides from Palestine by Blanckenhorn which even suggests some connection of the Middle Cambrian sea (which we now know extended from the Rocky Mountain region of western America across eastern Asia, the Himalaya, Salt Range and as far west as the Dead Sea) with the European Middle Cambrian Sea, of which *Paradoxides* was the dominant genus. This view was indeed suggested as long ago as 1915 by Diennmann [1] but did not receive sufficient notice. In this connection it may be remarked that according to King [2] the species *Anomocare campbelli* described by him from the Dead Sea region is closely allied to a British form, *Anomocare platycephalum* [3], and probably indicates marine inter-communication. While, therefore, it is true that 'no Mediterranean or ancestral tethys is proved by palaeontological evidence to have then been established, and the dissimilarities between the nearest European fauna and that of Spiti and the Salt Range are therefore marked', [4] the occurrences just mentioned provide additional proof of slight intermingling of the European and Asiatic seas.

We may now consider the evidence for the extension of the (Middle and Upper) Cambrian seas from Spiti to the Salt Range and beyond into Persia and Palestine in greater detail.

THE SALT RANGE CAMBRIAN.

EAST ASIATIC (INDO-CHINESE) AFFINITIES OF THE IRANIAN CAMBRIAN FAUNAS.

The generalized Cambrian succession in the Salt Range is as follows:—

Salt pseudomorph shales	..	Variegated flaggy beds of prevailing purple or green colour.
Magnesian sandstone	..	White or green sandstones, often dolomitic.
Neobolus shales	..	Fossiliferous grey or dark shales.
Purple sandstones	..	Red or purple sandstones.
Salt marl	..	Loose red earth or marl with salt and gypsum.

In an important paper published under the authorship of Böckh, Lees and Richardson [5] it is stated that

> 'the salt plugs of the Persian Gulf are overlain by purple sandstones, sandstones containing salt 'pseudomorphs' or sandy dolomites and shales containing Cambrian trilobites . .

[1] Diennmann, W. *Centralbl. fur Min. Geol. und Paläont.*, Vol. XVI, pp. 23–6, 1915.
[2] King, W. B. R. *Geol. Mag.*, Vol. LX, p. 511, 1923.
[3] Cobbold, E. S. *Quart. Jour. Geol. Soc.*, Vol. LXXVI, pp. 330–1, 1920.
[4] Reed, F. R. C. *Rec. Geol. Surv. Ind.*, Vol. XL, Pt. 1, p. 15, 1910.
[5] *Loc. cit.*, p. 84, 1929.

The sequence given above, showing the purple sandstone immediately overlying the Hormuz salt, corresponds with the salt Range succession '

Pilgrim's assignation of the Hormuz Series to the Jurassic [1] is of course entirely erroneous. The correlation of the Salt Range and Iranian Cambrian successions may therefore be considered established, but this correlation can only be a general one for the description of the Iranian and Salt Range Cambrian trilobites published [2] in recent years does not indicate close affinity between them, though it must be admitted that the number of species recorded is not large. The most noteworthy point therefore is that the Cambrian faunas of Iran are not related to those of Spiti or even the Salt Range but, on the contrary, as we shall presently see, they are closely related to East Asiatic, that is, Chinese and Indo-Chinese faunas. Relationship with Indo-China is especially marked by the presence of the genus *Billingsella*, the Iranian representative of which may be identical with *B. tonkiniana* from Indo-China. Lack of time prevents me from giving a detailed analysis of the faunas of these regions, but reference can be made to the works of Waagen [3], Redlich,[4] Walcott [5] and to the more recent papers by King [6].

AFFINITIES OF THE CENTRAL HIMALAYAN CAMBRIAN FAUNA.

In order to complete the picture I may now consider the Himalayan Cambrian. The evidence so far recorded establishes west American affinities for the Spiti Cambrian faunas. The Spiti species of *Anomocare* and *Ptychoparia* are allied to American forms, while the presence of such genera as *Zacanthoides*, *Oryctocephalus* and *Eocystis* in both regions is noteworthy. It is, however, equally remarkable that the Spiti Cambrian fauna is less affined to the nearer Chinese than to the American faunas, though the occurrence of the

[1] Drs. Böckh, Lees and Richardson, in their paper just referred to, state that the Iranian Cambrian sequence (Hormuz Series) as given by them does not agree with that given by Pilgrim in his latest Memoir (*Mem. Geol. Surv. Ind.*, Vol. XLVIII, Pt. 2, 1935). Surprisingly enough Pilgrim referred the Hormuz Series to the Jurassic apparently on purely hypothetical evidence, rather than to the Cambrian, and seems to have missed the fossil evidence completely. We may therefore reasonably accept the Hormuz succession as given by the first named authors rather than Pilgrim's.

[2] King, W. B. R. *Pal. Ind.*, New Ser., Vol. XXII, Mem. No. 5, 1937.

[3] Waagen, W. *Pal. Ind.*, Ser. XIII, Vol. I, 1887; *ibid.*, Vol. IV, 1891.

[4] Redlich, K. *Pal. Ind.*, N.S., Vol. I, Mem. No. 1, 1901.

[5] Walcott, C. D. *Proc. Washington Acad. Sc.*, Vol. VII, pp. 251–256, 1905.

[6] King, W. B. R. *Rec. Geol. Surv. Ind.*, Vol. LXXV, Professional paper No. 9, p. 40.

Chinese genus *Shantungia* in Spiti (apart from *Redlichia*) shows that free communication existed between these regions. The presence of many cosmopolitan genera like *Agnostus*, *Microdiscus*, *Anomocare* and *Ptychoparia* further emphasizes this connection though less importance is usually attached to such types. The occurrence of *Olenus* at Spiti further indicates a northern connection of the Himalayan Cambrian sea with the European sea, but with that we are not here concerned.

FAUNAL ANOMALIES AND THEIR PROBABLE EXPLANATION.

One fact of great importance which thus emerges is the marked divergence of the M. Cambrian faunas of Iran, the Salt Range and Spiti. The affinities of the Iranian Cambrian faunas with the far Chinese and Indo-Chinese to the exclusion of those of the Salt Range and Spiti raise some important questions concerning the routes of migration of these faunas and their inter-relationship. How are we to reconcile the diverging affinities of the Cambrian faunas of these regions ? Does this divergence postulate the occurrence of physical barriers or is it capable of some other explanation ? Let us for a moment examine the position.

This divergence suggests at first sight that the route of migration of the M. Cambrian faunas to Iran did not lie across the Salt Range region. Two alternatives are possible. Firstly it may be suggested that there was an independent connection between the Iranian and Chinese regions. There is however no evidence of this. Therefore the solution probably lies in the second alternative that so far as the M. Cambrian is concerned, the apparent discrepancies between the Iranian, Spiti and Salt Range faunas are probably due to differences in horizon within the Cambrian series, rather than to absence of direct communication between these regions.

This view is also suggested by recent work[1], as a result of which it has been established that the following succession of faunas occurs in Iran :-

4. *Saukia* fauna	..	High U. Cambrian
3. *Chuangia* fauna	..	Low U. Cambrian.
2. *Irania* fauna	..	Highest M. Cambrian.
1. *Redlichia* fauna	..	Basal M. Cambrian.

According to this view the Salt Range Cambrian corresponds approximately to horizon I. of M. Cambrian age where also the *Redlichia* horizon of Spiti belongs, while still higher beds in the Himalayan Cambrian probably fit into the gap between the *Redlichia* and *Irania* faunas of Iran.

[1] King, W. B. R. *Pal. Ind.*, New Ser., Vol. XXII, Mem. No. 5, 1937.

No Upper Cambrian strata have been found in the Salt Range. It may thus be maintained that in Upper Cambrian times the sea retreated from the Salt Range while it still persisted in Iran where the *Saukia* and *Chuangia* faunas then flourished, and probably also in the Central Himalaya where *Olenus* occurs and shows a northern connection with the Upper Cambrian *Olenus* sea of Europe. But if a post Middle Cambrian barrier (in the region of the Salt Range) separated the sea in Iran from its eastern continuation, we cannot expect to find the Iranian Upper Cambrian fauna affined to faunas further east of the Salt Range unless the barrier was of short duration. Such affinities, however, do exist and suggest communication via the Himalayan region.

The discoveries of Cambrian trilobites in Kashmir by the Yale North India expedition and by Wadia [1] appear to lead in a remarkable manner to this conclusion, for Cowper Reed has recently described the Upper Cambrian genus *Chuangia* from Kashmir [2]. It defines the basal Upper Cambrian horizon in Iran. This genus is thus common to Iran, Kashmir and Indo-China, and therefore the Kashmir region forms a definite link between Iran on the one hand and Indo-China on the other. The same is true of the Middle Cambrian. From Hundwara (Yale expedition collection) Kobayashi[3] has described a species of *Agnostus* which he compares with *A. rakurdenses* from Chosen in China. The form described by Reed [4] from Spiti as *Ptychoparia memor* has also been found in Kashmir though referred by Kobayashi to *Anomocarella*, and is compared with *An. megalurus* Dames, from Tonkin. More important still, the characteristic Indo-Chinese genus *Tonkinella* is now recorded from Kashmir [5] in the species *T. breviceps* Kobayashi. The occurrence of species of *Anomocare* and *Conocoryphe* in Kashmir which are closely allied to the Indo-Chinese species is likewise of great interest and emphasizes marine connection between these regions. The genus *Redlichia* has, however, not been found in Kashmir.

EASTERN ASIA.

East and south-east of the Central Himalayan region there is a big gap for no Cambrian strata are known either in Assam, in the Arakan Yomas or even in Burma proper.

[1] Wadia, D. N. The Cambrian-Trias sequence of North-Western Kashmir. *Rec. Geol. Surv. Ind.*, Vol. LXVIII, Pt. 2, pp. 137–142, 1935.

[2] Reed, F. R. C. *Loc. cit.*, p. 18, 1934.

[3] Kobayashi, T. *Amer. Journ. Sc.*, Ser. 5, Vol. XXVII, pp. 295–302, 1934.

[4] Reed, F. R. C. *Pal. Ind.*, Ser. XV, Vol. VII, Mem. No. 1, 1910.

[5] Kobayashi, T. *Loc. cit.*, Pt. 1, pp. 1–6. 1934. See also Reed, *Pal. Ind.*, N.S., Vol. XXI, Mem. No. 2, p. 9, 1934.

The eastward extension of the Cambrian sea is, however, proved by the occurrence of Cambrian fossils in Yunnan [1] (genus *Mesonachis*) Indo-China [2] (genera *Coosia*, *Chuangia*, *Billingsella*, etc.) and China. It was thought that the Chinese M. Cambrian possessed a marked local impress [3] suggested by the genera *Damesella*, *Drepanura* and *Blackwelderia*. In a paper by King [4] now in the press the probable occurrence of *Blackwelderia* in the Salt Range is noticed, and this is not without significance.

The discovery of *Chuangia* in Kashmir indicates clearly that the westward migration of Indo-Chinese forms lay along the Himalayan region, that discoveries of new horizons must be expected and that the supposed discrepancies between the Cambrian faunas of neighbouring regions (when those of distant areas are related) are probably due to slight differences in horizon of these faunas. Likewise the identification of *Blackwelderia* in the Salt Range suggests that much more remains to be done before we can explain the divergences of faunas by reasons other than by the absence of detailed information.

RECENT EVIDENCE BEARING ON CAMBRIAN PALAEOGEOGRAPHY.

We have seen that there is no certain record of the Lower Cambrian in Iran, unless the rocks at Kuh-i-banan and Kuh-i-dinar are so regarded, and that in all probability this horizon is missing also in the Salt Range. Further east, too, no Lower Cambrian strata are met with till we reach the Indo-Chinese region. We may therefore conclude, on the evidence at present available, that the Lower Cambrian in southern and western Asia was dominantly a continental period. Grabau, as also some of the earlier authors, however, regard the various *Redlichia* horizons as Lower Cambrian and in palaeogeographic maps the Lower Cambrian sea is shown to extend from China to as far as the Salt Range. Since *Redlichia* has now also been found in Iran the Lower Cambrian sea would according to these views extend into western Asia. More recent studies, however, regard the *Redlichia* horizons as basal Middle Cambrian, or possibly topmost Lower Cambrian. But the range of this genus may well be much greater than we suspect.

The Middle Cambrian was a period of widespread marine transgression and the Middle Cambrian sea extended from north-west America to western Asia, as far perhaps as the Dead Sea.

[1] Mansuy, H. *Mem. Serv. Geol. Indochine*, Vol. I, fasc. 2, 1912.
[2] *Ibid.*, Vol. IV, fasc. 2, 1915.
[3] Grabau, A. W. Stratigraphy of China, p. 28, 1923-24.
[4] King, W. B. R. *Rec. Geol. Surv. Ind.*, Vol. LXXV, Professional paper No. 9, 1940.

With the exception of the Salt Range area, the evidence of the Upper Cambrian faunas shows the perpetuation of Middle Cambrian marine conditions into Upper Cambrian times. But the close affinities of the west and east Asiatic faunas (Iran and Indo-China respectively) are strongly suggestive of a continuous passage, even though there was a temporary retreat of the Upper Cambrian sea from the Salt Range area.

As will appear presently, at the close of the Upper Cambrian period the sea retreated entirely from the region west of the Central Himalayan area.

ORDOVICIAN.

RETREAT OF SEA FROM WESTERN ASIA.

Towards the close of the Cambrian period a great change came over the western Asiatic region. The sea which, at least during the Middle and late Upper Cambrian times girdled the earth from the Mediterranean region to the western shores of North America receded from the region of the Dead Sea, Iran and the Salt Range, for no Ordovician or Silurian strata have so far been found in Iran, Afghanistan, Beluchistan or the western Himalayas. These areas thus became dry land. Indeed the whole of this region remained a land area till the Middle Devonian. In M. Devonian times a world-wide transgression gave rise to marine conditions once again and the seas flowed westwards over the site of the Cambrian geosyncline and broke through to mingle with the Middle Devonian sea of northern Europe.

THE PUZZLE OF THE HIMALAYAN AND SHAN ORDOVICIAN FAUNAS.

One of the most important and intriguing problems of the Ordovician of southern Asia is the anomalous position of the Himalayan and Burmese Ordovician faunas. Considerable emphasis is invariably laid on the fact that while the Burmese faunas are more closely allied to those of Europe, the Himalayan forms show American affinities.

Thus according to analyses by La Touche and Cowper Reed as many as sixty-six per cent of the Northern Shan State Ordovician species possess European affinities (10 being identical to the two regions), while only about twenty-seven per cent are related to American forms. On the other hand, as many as forty-two per cent of the Himalayan Ordovician fossils are believed to possess American affinities, though none of the species are common to these areas. The contrast between the Himalayan and Burmese faunas is equally well marked, for only 11 out of 124 Himalayan species are allied to Shan States forms and only three forms are identical in the two regions. The composition of the Himalayan and Shan faunas is also totally different, for

while Cystideans and Trilobites predominate in the Shan faunas, Mollusca, Brachiopods and Corals form the leading elements in the Himalayan fauna. We are thus once again face to face with the same problem that we meet in the case of the Cambrian faunas of Iran, the Salt Range, Himalayas and Indo-China. The Shan States Ordovician faunas lie along the route of the westward invasion of American faunas. How was it, then, that this invasion failed to leave an impress upon the Shan faunas while it gave the far Himalayan faunas their distinctive American stamp? The absence of American types, still further east or north-east, that is, in Burma and China, along the probable route of migration is no less a puzzle. And if it is sought to explain this anomaly by postulating an invasion from the south, via the region of the present Indian Ocean, then the absence of American species in the neighbouring regions still remains unexplained.

The American affinities of the Himalayan faunas when those of the Shan faunas are European as well as the striking contrast in their composition, have suggested the presence of barriers between the two regions. However, to any one familiar with the state of preservation of the Himalayan Ordovician fossils it seems obvious that too much emphasis has been laid upon their apparent American affinities, and sufficient cognizance has not been taken of the fact that we are probably dealing with varying horizons. Certain authors even believe that this apparent similarity is due to parallel evolution. Recent fossil discoveries in the Southern Shan States, accounts of which have been published by Reed,[1] seem to support the former hypothesis.

An analysis of the Southern Shan States faunas shows that most of the forms are new. And while the proportion of forms related to European species is comparatively large the fauna also possesses decided American affinities, though no distinctive American species occur. These fresh discoveries appear to indicate that while the European element in the Shan faunas is predominant it is not such in every case, the Southern Shan States, for example, as so completely mask the American element. One may therefore venture to suggest that we are not dealing with identical horizons and that the exact equivalents of the Himalayan Ordovician still remain to be discovered in the eastern region. Indeed the available evidence seems indirectly to point this way, for in the Himalayas strata of Upper Ordovician age are absent and only Middle Ordovician horizons are known. In the Northern Shan States, according to Reed,[2] only the Lower Ordovician is represented or rather the Lower Ordovician is definitely known, but higher horizons (stage C of the Baltic region) are probably present. The Nyawngbaw limestone of the

[1] Reed, F. R. C. *Pal. Ind.*, New Ser., Vol. XXI, Mem. No. 3, 1936.
[2] *Ibid.* *Pal. Ind.*, New Ser., Vol. II, Mem. No. 3, pp. 83–86.

Northern Shan States is of course of Upper Ordovician age and Schuchert concurs in this view on account of the occurrence of *Camarocrinus asiaticus* in it. In the Southern Shan States the Ordovician is represented by the Middle division, possibly also the Upper.

Another point to consider is that while there is an extensive development of the Orthoceras limestone in the Southern Shan States, these limestones are hardly known in the Northern Shan States. These limestones are correlated with the Orthoceras limestones of Yunnan and the Nechiasan formation of Hupeh which are of M. Ordovician age as are also the Orthoceras limestones of S. Manchuria, Karakorum, Sweden and the Vaginatenkalk of the Baltic region.

EASTERN ASIA.

Rocks of Middle Ordovician age are known from western Yunnan, but this formation appears to be entirely absent from eastern Yunnan. The western Yunnan[1] faunas however differ remarkably from those of the Shan States, for whereas graptolite horizons are extensively developed in the Yunnan Ordovician, these are not represented in the Naungkangyis, though a few species are common to the two regions. The horizon represented in Yunnan is the zone of *Didymograptus murchisoni* or Upper Llandelian. A still higher horizon, equivalent of the Nyawngbaw Limestone of the Shan States is represented in the Shih-tien beds in which *Camarocrinus asiaticus* occurs.

The Ordovician of Indo-China is of great interest, for although it is related to that of western Yunnan, it contains the species *Calymene douvillei* Mans. and *Rafinesquina umbrella* Salter of which the former is closely related to the Himalayan *C. nivalis* Salter while the latter actually occurs in the Himalayan Ordovician beds. In Annam the *Asaphus* sandstones represent the Ordovician, and, like the Tonkin beds, are of late Ordovician age. They contain such characteristic forms as *Orthis budleighensis* Dav. and *Strophomena expansa* Sow. of the north European seas.

Important changes took place in eastern Asia during late Upper Ordovician times. There are no uppermost Ordovician fossils found in the whole of the Chinese region which became a land area after the close of the Middle or early Upper Ordovician times. Lower and Middle Ordovician faunas are known from various parts of China and while the boreal facies prevails in the north, European forms are dominant in central and south-western China, as in Upper Burma.

[1] Reed, F. R. C. *Pal. Ind.*, New Ser., Vol. V, Mem. No. 3.

The absence of the highest Ordovician strata in eastern and southern Asia is evidence of a break of considerable magnitude and of the shrinking of the Ordovician seas of these regions During the Middle Ordovician, however, marine waters spread over parts of northern as well as southern China, Yunnan, Upper Burma (Shan hinterland) and sweeping south of the Tibetan plateau extended at least as far as the Central Himalayan region, where the Shiala Series [1] and their equivalents were deposited. West of this, the great Cambrian geosyncline which extended along the western Himalayas and the Salt Range and Iran had already shrunk out of existence and western Asia had become a land area.

WAS TIBET AN ISLAND?

We have seen that the Central Himalayan Middle Ordovician faunas possess an American impress, though I believe that this aspect of their affinities is often exaggerated. We have also laid emphasis on the fact that the probable route followed by these faunas is unknown and is still one of the puzzles of Asiatic geology. The palaeontological evidence so far available suggests only a single pathway for the eastward migration of the Ordovician faunas, namely, via the main Himalayan geosyncline south of the Tibetan plateau region, for there is no record so far of Ordovician strata north of this area. The American geologist Bailey Willis [2] in discussing the distribution of land and sea in central and eastern Asia, however, comes to the conclusion based, presumably, upon tectonic evidence that west of the Tibetan region the great Himalayan tethys forked into two branches: the main or Southern Tethys sweeping the southern shores of the Tibetan plateau and a lesser or Northern Tethys flanking this region on the north so that the Tibetan region stood as an island in this sea. This is designated *Isle Tibet* by Bailey Willis. The Southern Tethys, of course, corresponds to the universally accepted Himalayan Tethys founded upon palaeontological and stratigraphic evidence.

It is as yet too early to suggest whether the isolated character of the Spiti Middle Ordovician fauna with its American phase can be explained upon the basis of this northern ocean highway, for geologists have accepted only the single, Southern Tethys. But the tectonic evidence upon which the Northern Tethys is apparently based is of considerable interest

In this connection, however, the remarks made by Burrard, Hayden and Heron [3] may be quoted. They say, 'having regard

[1] Heim, A. and Gansser, A. *Denkschr. Schweiz. Naturforsch. Gesellsch.*, Bd. LXXIII, Abh. I, p. 203, 1936.

[2] Bailey Willis. Research in China. Systematic Geology, Vol. II. pp. 35–69, 1907.

[3] *Loc. cit.*, p. 338, 1934.

to our ignorance of the geology of the greater part of Tibet, we can offer no direct observations bearing on this question; but if we turn to north-eastern Ladakh, we find Palaeozoic rocks exposed in the neighbourhood of Changchenmo and Pangong Lake, and if, as appears to be the case, the trend of these beds is the same as that of the rest of the Tibetan zone in Kashmir, Spiti and Kumaon, we should expect to find them well to the north of the head-waters of the Indus and Brahmaputra in western and central Tibet. We are, therefore, inclined to believe that Palaeozoic beds do occur in the great lake-basin of central Tibet. They may possibly be hidden by the younger (Mesozoic) deposits . . . but it may reasonably be expected that they will be found to crop out here and there, and thus prove that the sea in which the Dravidian (Palaeozoic) rocks of the Tibetan zone were laid down was not, as has been assumed, merely a strait connecting eastern and western Asia, but extended northwards over the greater part of Tibet.'

INVASION OF THE EUROPEAN ORDOVICIAN FAUNA INTO SOUTHERN ASIA.

Very little indeed is known concerning the route followed by the European Ordovician faunas during the course of their invasion of the south Asiatic region. But it is a remarkable fact, one that demonstrates the accuracy and fineness of palaeontological correlation that some at least of the graptolite zones of the British Ordovician (*Didymograptus murchisoni*), the fine development of the Orthoceras Limestone of Sweden and other Baltic lands, and such characteristic Caradocian species of western Europe as *Orthis calligramma*, *Orthis vespertilio*, *Dalmanella testudineria*, *Plectambonites sericea*, *Strophomena expansa* have also been recorded either in the Ordovician strata of the Shan hinterland or Yunnan or southern China. We have unfortunately no record of Ordovician strata north or west of the central Himalayan region till we meet the Ordovician strata of western Europe already referred to. We can therefore but speculate on the marine connection between the Indo-Burmese region and Europe, but it probably followed a north-westerly course from the central Himalayas to the present Baltic region. In this connection I must refer to the find of graptolites[1] (genus ?*Diplograptus*) made by Harrison and Tait, of the Anglo-Iranian Oil Company, "at Furgun, 50 miles west of Bandar Abbas, close to the front of the zone of Nappes". This find if confirmed possesses considerable significance where the migration of Ordovician faunas is concerned.

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[1] Böckh, H. de, Lees, G. M. and Richardson, F. D. S. *Op. cit.*, footnote, p. 69, 1929.

SILURIAN.

LOWER SILURIAN TRANSGRESSION IN THE INDO-BURMESE AND CHINESE REGIONS.

The close of the Ordovician or early Silurian marks a period of profound marine transgression over India, Burma, Indo-China, Yunnan as well as central and southern China. Indeed this transgression which appears to have reached its zenith in Wenlock times, affected the European continent as well as north America: and 'one common Silurian ocean seems to have spread round the northern hemisphere'.[1] But with the extra-Asiatic aspects of this problem we are not here concerned.

No Silurian strata have been found in the Asiatic countries west of the Himalayas and therefore the extension of the Himalayan Tethys into Afghanistan, Beluchistan and Iran is uncertain. The first strata of this age that we meet in that direction are in the Mediterranean region. It may be mentioned that the same remarks were applicable to the Cambrian (except for its occurrence in the Salt Range) till the discovery in Iran of extensive deposits of Middle and Upper Cambrian ages.

THE HIMALAYAN SILURIAN.

Our knowledge of the Silurian strata of the Himalayan region has not increased during recent years even though considerable exploratory work has been carried out by Wadia, Arnold Heim, West, Auden and others. The old collections upon a study of which the main conclusions concerning the relationship of the Himalayan Silurian faunas were based still remain practically unsupplemented by fresh discoveries, which leaves, it need hardly be said, a big lacuna in Himalayan palaeontology.

The Silurian rocks of the Himalayas belong entirely to the Lower Silurian division, being represented by the Llandovery and possibly also by the Wenlock. The presumed Upper Silurian age of some of the Himalayan beds appears to be uncertain. There is here as indeed everywhere in Asia a profound break in the marine depositional history so that the Middle Silurian is either entirely absent or is represented only by terrestrial deposits, as in parts of America, where this division constitutes the well-known Salina formation.

The Himalayan Lower Silurian fauna presents interesting affinities which throw much light on the palaeogeographic relationships of that period. This fauna is composed of (*a*) species which are confined to the Himalayas, (*b*) species that are either identical with or allied to north European forms and (*c*) an admixture of species allied to American forms.

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[1] Reed, F. R. C. *Rec. Geol. Surv. Ind.*, XL, p. 26, 1910.

La Touche has attempted a percentage analysis of this fauna and comes to the conclusion that the Himalayan Silurian contains an almost equal proportion of American and north European forms, fifty-one and forty-nine per cent respectively, to be more exact.[1] It will be remembered that in the case of the Himalayan Ordovician this proportion according to the same authority was 42 per cent to 25 per cent, which means a predominating American element. In this connection it may be pertinent to remark that while in the case of the Ordovician fauna the analysis was based upon 124 species, only 35 species were available for the Silurian. We cannot sufficiently emphasize the fallacy of such comparisons and analyses where the collections are inadequate, the fossils far from well preserved and where in consequence it is impossible to adjudicate the relative degree of their affinities. That this is not a hasty verdict may be shown by the fact that Reed, who published the studies on these Himalayan fossils, assigns predominantly north European affinities to them. The large number of corals in the Himalayan Silurian in comparison with the Burmese Silurian, however, show distinct American affinities and among them one form appears almost identical with *Favosites niagarensis* Hall, from the American Silurian.

The Silurian formation in Kashmir must be assigned to the Lower division,[2] namely, Llandovery, on account of the presence of such forms as *Triplecia insularis* Eichw., *Orthis sowerbyana*, *Lindstroemia* cf. *bina* (Lonsd.). Species of *Acidaspis* and *Illaenus* likewise possess Llandovery affinities. It is, however, probable that the presence of *Conchidium knighti* at a different locality indicates the Aymestry Limestone, a horizon high up in the Salopian.

However, the main upshot of this discussion with which we are primarily concerned here is that the occurrence of both American and north European forms postulates marine connection of the Himalayan geosyncline with both these regions during Lower Silurian times. The probable route followed by these faunas will be considered presently.

AFFINITIES OF THE SHAN SILURIAN.

PREDOMINANT SHELLY FACIES OF THE NORTHERN SHAN STATES.

We have already drawn attention to the dominantly North European character of the Shan Ordovician fauna. It is perhaps,

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[1] La Touche, T. H. D. *Mem. Geol. Surv. Ind.*, Vol. XXXIX, p. 161, 1913.

[2] Reed, F. R. C. *Rec. Geol. Surv. Ind.*, Vol. XLII, Pt. 1, pp. 16–33, 1912.

therefore, not surprising that the Shan Silurian faunas are also strikingly North European in character which is expressed by such species as *Halysites catenularia* Linn., var. *kanaurensis* Reed. *Orthis* (*Dalmanella*) *lasalis* Dalm., var. *muthensis*, *O. calligramma* Dalm., *Leptaena rhomboidalis* Wilck., *Stropheodonta compressa* (Sow.), *Pentamerus oblongus* Sow., *Orthoceras* cf. *annulatum* Dav., *Encrinurus* cf. *punctatus* Brunnick. The only South European type is *Mimulus*. Most of these are Wenlock species and in the Northern Shan States this shelly facies predominates. This conclusion is borne out not only by the earlier work of La Touche but also by the studies based upon recent collections made by Coggin Brown, Sondhi and myself. Concerning the Zebingyi beds which are usually placed in the Silurian more will be said later.

PREDOMINANT GRAPTOLITE FACIES OF THE SOUTHERN SHAN STATES.

To Sondhi goes the credit of discovering the first graptolites in the Southern Shan States. In this region the graptolite facies is very much more widespread than the shelly facies, the reverse in fact of the position in the Northern Shan States. The palaeontological accounts published by Cowper Reed first in 1932[1] and again in more exhaustive detail in 1936[2] show clearly that the Valentian stage is well developed while the Wenlock stage is subordinate. In both horizons, however, the North European affinities are predominant. In the Namshin stage for example out of 45 species as many as 27 are identical with European Wenlock forms. Slight discrepancies have, however, been noticed, but we cannot take account of them in the brief space of this address. It is also worthy of remark that the Trilobite beds of Panghsa-pye (Northern Shan States) have not been found in the Southern Shan States.

RELATIONSHIP BETWEEN THE SHAN AND HIMALAYAN SILURIAN.

The important point to consider now is the relationship between the Himalayan and Burmese Silurian faunas. We have seen that the Ordovician faunas of these regions present a marked contrast, though how far this contrast is emphasized by imperfections of the geological record or indifferent state of preservation it is not easy to say. However that may be, the Silurian faunas present an even greater contrast than the Ordovician for the graptolite facies which is so well developed in parts of Burma as well as Eastern Asia is entirely absent in the Himalayas and no graptolites have so far been found in any part of the Himalaya mountains.

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[1] Reed, F. R. C. *Rec. Geol. Surv. Ind.*, Vol. LXVI, Part 2, 1932.
[2] *Ibid. Pal. Ind.*, New Ser., Vol. XXI, Mem. No. 3, 1936.

As a result of this apparent faunal divergence La Touche emphasizes the presence of an 'unsurmountable' barrier between the Himalayan and Burmese regions from the Ordovician till the close of Silurian times. When we consider the very limited thickness and the usually soft shaly character of the graptolite beds, it becomes difficult to assert how far this lacuna is the result of difference in facies or actual absence of record or of their not having been found so far in the Himalayas. Moreover, if we do not take into account the exclusively Himalayan species such as *Propora himalaica, Caliostylus dravidiana, Favosites spitiensis, Orthis spitiensis*, etc., practically 25 per cent of the remaining species are either identical with or allied to North European forms found in Burma, and at least one species, *Encrinurus punctatus*, is closely allied to an exclusively Burmese species. Although it is true that almost all of these are cosmopolitan forms, yet their number is comparatively so large when the entire known fauna is considered (35 species in all) that we seem to be on fairly safe ground in postulating a freer marine connection than La Touche's remarks and analyses would have us believe, between the Himalayan and Burmese regions. This was so at least during Wenlock times, that is to say following the period (Lower Valentian) when the graptolite beds of the Southern Shan States were being deposited.

SILURIAN OF EASTERN ASIA.

The continuation of the Lower Silurian sea into Western Yunnan and Central China is proved by the presence of fossils of North European type and other forms which are profusely represented in the Shan Silurian. 'This fauna entered the Chinese basin through the Himalayan geosyncline, passing north along the West Yunnan-Szechuan geosyncline and spread in the Tsingling geosyncline as far east as the Nanning hills region of to-day. It was represented partly by a trilobite and brachiopod facies, partly by a pelecypod facies and in certain sections where deltas of mud were forming near the shore, it is represented in the graptolite facies [1].'

This last fact assumes importance when we remember that the graptolite facies is considerably developed in the Southern Shan States, which implies that the Shan Lower Silurian sea did not extend much further south of the Southern Shan States. This is of course apparent from other geological considerations.

RETREAT OF THE LOWER SILURIAN SEA FROM ASIA: UPPER SILURIAN TRANSGRESSION.

The end of the Lower Silurian marks a period of profound negative movement of the sea in Asia as well as outside the

[1] Grabau, A. W. Stratigraphy of China, Part I, p. 35, 1923-24.

Asiatic continent. The seas withdrew along the entire length of the Himalayan region, from Burma, Indo-China as well as from the whole of the Chinese basin. No Middle Silurian marine deposits are known from any of these lands. Northern China, it may be remarked, was already a land area even in Lower Silurian times and remained such till the advent of the Middle Devonian.

The Indo-Burmese region as almost the whole of Western Asia appears to have remained a land area during the Upper Silurian as well. The recent surveys by Coggin Brown and Sondhi in the Southern Shan States and by myself in the Northern and Southern Shan States have not revealed any strata of undoubted Upper Silurian age in Burma.

While the whole of Asia appears to have remained a land area from the close of the Lower Silurian to the end of the Upper Silurian, a minor transgression with an American type of fauna invaded parts of Yunnan, Tonkin and the neighbouring region to the east of it in Upper Silurian times. This invasion was in all probability from some southern source, for no Upper Silurian rocks are found to the east of these regions which would connect the American Upper Silurian Sea with the South Chinese basin across Eastern Asia. It is only to be expected that this fauna coming after a hiatus of great magnitude represented by the lapse of the Middle Silurian, was totally different to the Lower Silurian fauna of these regions. This striking discord is most significant, for while the Lower Silurian fauna is North European, this Upper Silurian fauna bears an American stamp. There appears, therefore, to have been no manner of connection between the North European and South Asiatic seas in Upper Silurian times. With the Lower Silurian seas, however, the case as we have already seen was entirely different, for they were in close intercommunication. But what was the route followed by these invading North European Lower Silurian faunas into Asia? The southern end of this route appears to be quite clear, for we have followed the distribution of the European faunas through the Himalayan region across, Burma, Indo-China into the main Chinese basin. It is when we attempt to trace this pathway across Central Asia that difficulties arise. The earlier work suggests that the route lay across Russian Turkestan and Timan where Silurian faunas have been discovered. I am unable at this stage to say whether more recent work of the Russian geologists (usually in Russian) has been able to define more precisely this connecting link between Asia and Europe.

DEVONIAN.

LOWER DEVONIAN (ZEBINGYI BEDS). A MEDITERRANEAN FAUNA IN SOUTHERN ASIA.

The commencement of the Devonian witnesses one of the most interesting episodes in the geology of Southern Asia,

namely, the sudden influx of a fauna which bears no relation to the faunas of immediately surrounding regions, but is a prototype of the far Mediterranean Lower Devonian fauna. It is the fauna which is represented in the Bohemian region by the well-known Hercynian facies.

This influx is the more remarkable, for whether in the Himalayas or the Shan hinterland the earlier strata betray hardly any suspicion of Bohemian or South European elements. Some of the exceptions, to which attention has already been drawn, are the presence of the genus *Aristocystis* (*A. dagon*) in the Ordovician and of *Mimulus* (*M. aunglokensis*) and a species of *Phacops* in the Silurian strata of the Northern Shan States. The percolation of these South European types in the earlier Ordovician and Silurian times probably indicates only an indirect connection with that region, for we have seen that direct connection during this period was with the North European seas.

At all events this episode is but an isolated phenomenon, for apart from the Shan region this fauna appears to have made but little headway. Its isolation becomes the more striking when we realize that we have but few intervening connecting links between Southern Europe and Asia so that the probable pathway of migration of this fauna still remains a matter of speculation.

AGE OF THE ZEBINGYI FAUNA.

The most interesting and puzzling fact about this fauna is, however, not its isolation and Hercynian affinities, but its composition, which makes the question of its exact age indeed a perplexing problem. These beds contain closely associated with each other forms which we are accustomed to regard as exclusively Devonian (*Tentaculites elegans* Barrande and the genus *Styliolina*) or exclusively Silurian (*Monograptids*). What then is the age of these beds, Silurian or Devonian? The author as a result of field examination in 1929 came to the conclusion that in their stratigraphical relations the Zebingyi beds are more closely associated with the overlying Plateau Limestone than with the underlying Ordovician beds, and in this respect agreed with the observation made earlier by La Touche. La Touche [1], like Grabau [2], inclines to a definitely Silurian age on account of the graptolites; Schuchert [3] is definite about their Lower Devonian age in spite of the graptolites. While Reed [4] although he includes them under the Silurian section appears to

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[1] La Touche, T. H. D. *Mem. Geol. Surv. Ind.*, Vol. XXXIX, p. 178, 1913.

[2] Grabau, A. W. Stratigraphy of China, Pt. I, p. 121, 1923-24.

[3] Schuchert, C. *Amer. Journ. Science*, Ser. 4, Vol. XXV, p. 262, 1908.

[4] Reed, F. R. C. *Rec. Geol. Surv. Ind.*, Vol. XL, Pt. 1, pp. 26-27, 1910.

incline to the Devonian view and points out that Devonian graptolites have been described by Ruedmann.[1] In my opinion the fauna as a whole indicates the Lower Devonian. Through the maze of this conflicting evidence it seems impossible to sift and assign a precise age to these beds, but if we weigh the evidence upon its merits and forget our preconceived bias that graptolites were annihilated at the close of the Silurian, I think the Zebingyi beds should be assigned to the Lower Devonian. The conformable passage of the Zebingyi beds into the overlying Plateau Limestone likewise supports this conclusion, though there cannot be any finality about such evidence.

PROBABLE PATHWAY OF MIGRATION.

Other areas in Asia where the South European type of faunas have been found are in the neighbourhood of Baroghill pass [2] in Chitral, in Turkestan [3], in the Urals [4] and in the region to the north of Tibet.[5] Now although Grabau remarks upon the 'very close connection which exists between these central Asiatic faunas and those of the corresponding age in the Urals', yet there appears to be very little in common between them and the Lower Devonian Zebingyi fauna of the Shan States.

What then was the sea-route of this (Zebingyi) fauna during its long journey to Asia? Indeed was this fauna one of European origin at all, which had migrated to Asia or was it, as the presence of Graptolites might indicate a fauna established in some nearby Asiatic region, which had in course migrated westwards into the south European basin?

There appears to have been but little connection with the Urals, for with the exception of the lamellibranch genus *Vlasta*, there is not much in common between these Hercynian faunas of the Urals and the Shan States. There is further no evidence whatever in the Himalaya mountains of a Hercynian fauna, even if we are to accept the Muth Quartzites as the probable equivalent of the Zebingyi beds. But since there is no trace of the Lower Devonian in Iran which would offer a direct connection of the Shan with the Mediterranean region, one can only accept a connection via the Urals already vaguely implied by the genus *Vlasta* which occurs in Bohemia, the Urals, Zebingyi beds and even in America. The genus *Vlasta* it must be stated is usually

[1] Ruedmann. New York State Museum, Mem. No. 7, 1904.

[2] Reed, F. R. C. *Rec. Geol. Surv. Ind.*, Vol. XLI, Pt. 2, pp. 86-87, 1911.

[3] Muschketow, D. *Neues Jahrb. für Min. Geol. und Paleontol.*, Bd. I, pp. 25–42, 1914 and Weber, *Bull. Com. Geol. St. Petersbourg*, Vol. XXIX, pp. 603–695, 1910.

[4] Tschernyschew, Th. *Mem. Com. Geol.*, Vol. IV, 3, 1893.

[5] Hayden, H. H. *Mem. Geol. Surv. Ind.*, Vol. XXXVI, p. 34, 1912.

assigned to the Silurian. What is the exact value of this evidence I shall leave to your taste and inclination.

In this connection, in my opinion, much significance attaches to the occurrence of the Hercynian fauna north of Tibet, meagre though it is. If the Zebingyi fauna is an immigrant from Central Asia or further afield from Europe, it is not improbable that it came via the region north of Tibet and found its way into the Shan region via the eastern margins of Tibet and the Chinese provinces north of the Shan plateau. But future work alone can show how far this surmise is correct.

MIDDLE DEVONIAN.

The marine transgression which took place in Middle Devonian times has few parallels in the geology of Asia. This resulted not only in the intermingling of the Asiatic fauna of different regions, but also as emphasized by Reed in the breaking down of barriers of Asiatic and European life provinces which gave rise to similar faunas in widely separated regions. Attention has already been drawn in this connection to the identical character of the Eifelian faunas of the Shan States and Northern Europe.

On the present occasion I can hardly hope to review in detail the Devonian faunas of Asia, for it is a subject upon which a great deal has been written.[1] I can, therefore, do little more than put forward before you the salient aspects of this problem.

Very little has been added to our knowledge of the M. Devonian faunas of Western Asia in recent years. Mention may be made of a paper by Cowper Reed[2] entitled 'Devonian fossils from Chitral, Persia, Afganistan and the Himalaya'. The same remark applies to the Himalayan region, for no Middle Devonian fossils have been recorded from any part of the Himalaya in recent years. Of the few records mention may be made of the Middle Devonian occurrences in Byans, Kanaur and Upper Spiti described by Reed in the paper just referred to. In Burma too until recently the only known Middle Devonian fauna was the classical Padaukpin (Northern Shan States) fauna discovered by La Touche over thirty years ago and described by Reed in 1908. The only addition after the lapse of three decades is the find I was fortunate enough to make a few years ago of highly fossiliferous Middle Devonian beds near the village of Meso in the Southern Shan States. This constitutes the only record of Devonian fossils in the Southern area. It is unnecessary to give a complete list of the fossils found here, but among others the

[1] For detailed references various memoirs cited by Lorenz in *Zeitschr. Deutsch. Geol. Gesellsch.*, Bd. LVIII, p. 120, 1906 and by Cowper Reed in *Pal. Ind.*, New Ser., Vol. II, mem. No. 5, 1908, may be consulted.

[2] Reed, F. R. C. *Rec. Geol. Sur. Ind.*, Vol. XLI, pt. 2, pp. 106–112, 19.

following species are represented [1] *Spirifer* (*Reticularia*) *curvatus*, Sp. (*Retic.*) *aviceps* Kays., *Cyrtina heteroclyta* Defr., *Spirifer speciosus* Schloth. var., and new species of *Platyceras*, *Pleurotomaria*, *Meristella*, etc. Although *Calceola sandalina* has not been recorded, the age of these beds appears to be Middle Devonian (Eifelian). Middle Devonian faunas corresponding in age to those of the Northern and Southern Shan States (Eifelian) are found further east in Yunnan [2] and Indo-China. [3]

We have thus an almost continuous record of Eifelian strata from Armenia in the west to the Chinese basin in the east. They indicate according to Grabau [4] the

> 'general direction of transgression of the early Middle Devonian Sea, which extended probably from the region of the Bosphorus [5] across Asia Minor and Persia, into the heart of Southern Asia along the Southern border of ancient Caucasia. That the ancient passageway along the Himalayan geosyncline was again open at this time, is shown by the extensive development of the Eifelian fauna at its eastern end, in the Northern Shan States of Burma as well as the presence of this fauna in South-Western China (Yunnan) and Indo-China'.

The recently discovered Southern Shan States fauna constitutes a further link in this chain.

The record of the upper part of the Middle Devonian (Givetian stage) is less clear in Western Asia as well as in the Himalayan region. Certain it is, however, that a transgression in Givetian times flooded the present region of the Kwen-lun and Tian Shan mountains. Rocks of this age also occur extensively in China though the zone fossil *Stringocephalus burtini* has so far been found only in Yunnan. Up to the end of the late Middle Devonian (Givetian) times, however, there is no fossil record indicating that the western part of the Devonian sea was connected with the Chinese basin via the region north and east of the Tibetan region. In other words, the only connection seems to have been via the Himalayan geosyncline, where Eifelian strata are known.[6] This is significant in view of what follows.

UPPER DEVONIAN.

Exigencies of time do not permit me to consider the Upper Devonian here in detail, but one fact of great importance may

[1] Sahni, M. R. *Proc. Twenty-fifth Indian Science Congress*, Pt. III, Abstracts, p. 114, 1938.

[2] Mansuy, H. Étude geologique du Yunnan oriental, IIe partie, Paléontologie. *Mem. Serv. Geol. Indochine*, 1912; *Ibid.*, Vol. III, fasc. II, pt. 1, 1914; Grabau, A. W. *Pal. Sinica*, Ser. B, Vol. I, Fasc. 2.

[3] Mansuy, H. Contrib. Carte Géol. Indo-Chine, Palaeont. (Sérvice des Mines, Hanoi-Haiphong, pp. 2, 3, 15–20, 1908).

[4] Grabau, A. W. Stratigraphy of China, pp. 155-156, 1923-24.

[5] Abdulla Bey. Remarques Géologiques sur le calcaire dévonien du Bosphore. *Boll. del R. Comit. Geol. D'Italia*, Vol. I, p. 187, 1870.

[6] Hayden, H. H. *Mem. Geol. Surv. Ind.*, Vol. XXXVI, Pt. I, p. 20, 1904.

be mentioned. It is that we have no record of Upper Devonian rocks in the Himalayan region, which was then presumably a land area. But Upper Devonian strata are developed in the Chinese basin, in the region north of Tibet and west of the Himalayas. It is, therefore, probable that the Upper Devonian fauna migrated eastwards from Western Asia via the marine basin north of Tibet while (as we have seen) the Middle Devonian fauna found a passage-way South of the Tibet region, i.e. via the Himalayan geosyncline. Against this, however, are the views expressed by Bailey Willis who considers that the Tibetan region was an island practically throughout the Palaeozoic era. Bearing in mind this conflict of views we can merely emphasize that final judgment can be left only to future work.

CONCLUSION.

I have attempted to present before you a panoramic view of the sequence of geological events that have moulded the palaeogeographical history of the Asiatic continent and more particularly of the Indo-Burmese region, from the Vindhyan to Devonian times. This we may now summarize. If the mighty Himalayan ranges constitute an effective barrier at the present day separating the mountain tracts of the north from the plains of India, the hand of destiny has assigned this rôle to that region, in one way or other, almost since the dawn of geological time; for even in the Vindhyan period we recognized the germs of a great geosyncline, which was to dominate the geography of Southern and Eastern Asia practically throughout the Palaeozoic era. During the Cambrian this geosyncline girdled the Northern Hemisphere from Western North America to the shore of the Dead Sea. Since then this ancient Mediterranean Sea has waxed and waned with varying fortunes at different periods. The Ordovician and Silurian saw its retreat from the whole of Western Asia. But that a marine connection was maintained during these periods with the European seas is proved by the presence of many European species in the Himalayas, in Upper Burma and in the Chinese basin. A new passage-way across Central Asia had, in fact, opened up and remained so till the close of the Silurian. During the profound Middle Devonian transgression the site of the ancient Cambrian geosyncline (in Western Asia) was rejuvenated, so to speak, and once again formed the route of migration of European faunas.

The Himalayan region remained a marine area practically throughout the period under consideration, except perhaps during the Middle Silurian when a world-wide negative movement of the seas set in, and in a lesser measure during the Upper Devonian, when according to the available evidence the sea temporarily retreated from the Himalayan geosyncline.

The problems of divergence between the Himalayan and Burmese Ordovician faunas, of the relationship between the Iranian, Indo-Chinese and Himalayan Cambrian faunas, of the invasion of Bohemian or Mediterranean faunas into Asia, have been raised and discussed in the light of their palaeogeographical bearing, but I can hardly claim that suitable solutions have been attained. Considering the importance of the problem one can only regret that our knowledge of the Himalayan palaeozoic faunas, already meagre, has not been supplemented in any substantial measure by fresh discoveries, and the void remains.

Our knowledge of the continental boundaries during the periods under review is far from conclusive though restorations have been suggested by various authors. But we know enough to be able to say that the seas and continents have undergone profound changes through the vicissitudes of Geological time and the map of the world has altered almost like the varying stages of a child's jigsaw puzzle. In short, one might say that our mother earth is like a ball of plastic clay in the hands of a Modeller and the same Modeller that makes and unmakes the destinies of men and races also shapes and unshapes the oceans, the great continents and the islands that stand like sentinels on the ocean highways. The impact of Geological forces has changed the face of many continents and if a mere man of science may dare to preach a moral to the warring nations of the world, in this age of stress and strife, it could be said that the continents which they seek to conquer and possess are, in the infinitude of time, like the patterns of a cloud—an illusion and a chimera.

SECTION OF GEOGRAPHY AND GEODESY

President:—S. M. TAHIR RIZVI, B.A., PH.D., M.A., F.R.G.S., F.R.MET.S.

Presidential Address

(*Delivered on Jan. 6, 1941*)

CONSERVATION OF INDIA'S NATURAL RESOURCES.

LADIES AND GENTLEMEN,

I thank you most heartily for the honour you have done me by electing me to preside over the deliberations of the Geography and Geodesy Section of the Indian Science Congress of this session. I am conscious of the great responsibility placed on my shoulders but, counting upon your kind co-operation and forbearance, I shall try my best to fulfil the task in as best a manner as could be possible.

INTRODUCTION.

Few problems in India are of more vital importance than the conservation of the natural resources of the country on a planned basis. To-day, public consciousness needs more than at any other time of Indian history to be rightly educated as to the existence and utilization of abundant natural resources of the country. I have, therefore, selected the conservation of India's natural resources as the subject of my address as it is a subject of general interest as well as of vital importance to our nation.

Whereas the growth, greatness and survival of a nation depend largely on the natural resources of the country, their conservation seeks to insure to society the maximum benefit from their use. Thus conservation of natural resources such as soil, forests, water and minerals, without which the very existence of a nation may be at stake, should, therefore, unquestionably be one of the most important matters for the consideration of those who are entrusted with the responsibility of formulating programmes of national reconstruction.

Conservation of natural resources is a timely field of action in India. The growth of population in this subcontinent has been accompanied by an unprecedented destruction of the

natural landscape. Moreover, as the country awakens politically and the limits of its resources and the character of its need begin to appear more fully, the necessity for greater care in the utilization and renewal of resources becomes imperative indeed. The movement is a timely one being in line with a worldwide concern regarding the material bases of national well-being.

There is no doubt that conservation is a field of vast national importance and of such magnitude and range as to demand the co-operation of nearly everyone. Contributions to its theory and practice may be made by the layman and the scientist, by the philosopher and the practical man of affairs, by the social scientist and the natural scientist. In one way or another, each of the natural and social sciences can give, and, indeed, is giving, some assistance, directly or indirectly. The scientific geography though still in its infancy in India is contributing to the field of conservation both theoretically and practically. Studies in systematic and regional geography are greatly helping to build up our knowledge of our natural resources and the problems arising from their exploitation. Geographers are also taking an active part in the practical application of their viewpoint and techniques to problems facing the nation. Moreover, they are imparting useful knowledge of the principles and practices of conservation in the colleges, and in a small measure at elementary and secondary schools. The rising generation is, therefore, learning largely through geography teachers and text-books about the aims and practices of conservation. However, it is not meant, in any sense, to imply that teaching in this field is exclusively the function of geography.

As the subject selected by me is a very wide one it would not be possible for me to discuss it fully in the short time at my disposal. I have, therefore, limited my address to three aspects of the problem, that is to say, conservation of soils, forests and water resources.

SOIL.

The soil of a nation is its most material heritage. It nurtures the ever-flowing stream of vegetation from which men and their animals derive their sustenance. The preponderance of the world's organic raw materials as well as its food supplies arise from soils through the practice of agriculture. The great civilizations of the centuries have rested fundamentally upon uncountable millions of fields planted and tended by man.

The civilization of this country has been and is based upon its soil resources and great agricultural industries. Our country taken as a whole possesses such a combination of soils and climates that it suits admirably to agriculture and no less than

nine-tenths of the population of India to-day is engaged, directly or indirectly, in agricultural pursuits. Soils are subject to certain changes when cultivated or pastured. Change in itself is not a critical matter since eternal change is a fundamental law, for, were this not true, it is doubtful if man could have survived. The critical aspects arise when changes in soils that are subject to human manipulation are left to take a degenerative course, or are improperly directed, and when known means of maintaining the soils near their virgin level or raising them to higher levels of productivity are not employed.

These critical aspects obtain rather generally in India. At the end of several centuries of agriculture and pastoralism, the soils in India are in a lower state of fertility than our scientific and practical knowledge should tolerate. Especially serious is the fact that some soil areas have so seriously deteriorated that their early reclamation will be extremely difficult and costly, if not nearly impossible. This is particularly true of the gross physical destruction of the soil body occasioned by erosion. More subtle but almost equally serious is the state of chemical, physical and biologic degradation into which we have allowed our soils to drift. The causes are many. We have not fully appreciated either the limitations or capabilities of our soils. They were and are looked upon much as a mine, as simply possessing a store of plant food: when these had been extracted there was little we could do except abandon the land until it somehow recuperated. Moreover, since the keynote of Indian agriculture has been primarily self-maintenance, systems of cropping were so shaped as to yield the maximum results regardless of the tolls on the soil. Whatever the causes the general results are equally deplorable.

Soil Erosion and its Causes.

Within the last few years we have learnt that erosion, far from being a harmless or completely beneficial process in all its manifestations, is a living, constant menace to our own security and the security of posterity. We have learnt that the process does not remain at geologic norms when human factors intervene in the natural order of dynamics pertaining to the earth's surface. We know definitely that man's misguided use of the land has accelerated this ancient earth-process until it has overwhelmed enormous areas of once fertile land and impoverished even greater areas. In the light of this knowledge erosion becomes a matter of concern to everyone; since it constitutes a threat to the principal factor in our country's security—our indispensable agricultural lands.

Accelerated erosion is the result of conflict between man and nature—of man's necessary interference with natural processes of land stabilisation in order to provide himself with the necessities

of existence. Under a blanket of vegetation, nature protects the soil from the erosive forces of wind and rain and her protection is almost complete. Soil losses under natural conditions of vegetation cover are negligible—so small, in fact, that normal processes of soil-building are generally adequate to compensate for them.

Faced with the problems of existence, man strips away the protective cover of vegetation, and thus rudely interferes with nature's balance. Soil is exposed to winds and rain and rates of erosion are increased almost enormously. Cultivation still further exposes the soil to the cutting force of wind and flowing water, again accelerating the rates of wastage. In the one instance—under natural vegetative conditions—therefore, erosion is normal or geologic; in the other—under cultural practice—the process is speeded to abnormally destructive rates. Soil erosion has thus become a worldwide problem owing to the way in which ploughing and grazing have destroyed the plant cover which Nature originally provided to protect the earth's cover.

Types of Erosion.

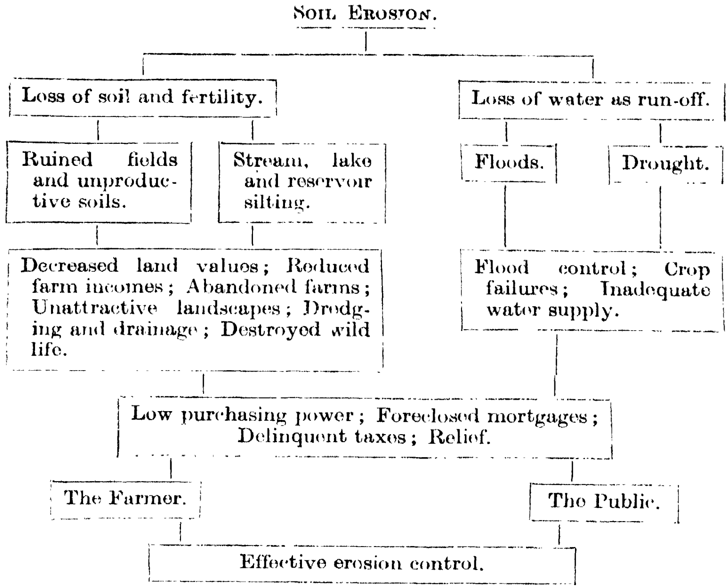
There are, broadly speaking, three types of erosion: sheet erosion, gully erosion, and wind erosion.

The first is the most widespread and dangerous, being the principal agency of soil impairment, for it can do great damage before it becomes apparent to the farmer. Sheet erosion characteristically proceeds so slowly that farmers themselves generally have not understood it and, accordingly, have given little attention to its effects until out-croppings of infertile sub-soils or bed-rock appear over their sloping fields. The process involves removal of thin sheets of soil over the entire extent of unprotected areas with every rain heavy enough to cause water to flow across the slopes.

The first effect, which often goes unnoticed, is the removal of the finer soil particles in suspension, leaving the coarser particles behind. These finer parts of the soil are valuable because they help to bind the soil into crumbs. The capacity of the soil to retain moisture and soluble plant food depends largely upon this crumb structure. If the finer particles are lost by sheet erosion the soil deteriorates. In extreme cases the whole of the top soil is removed bodily, leaving behind only an infertile sub-soil of clay or gravel. Sheet erosion is common throughout India except in areas irrigated by canal or well, but is of course more serious on all sloping land.

Gully erosion is much more obvious and it is easy enough to see and understand the deadly malignancy of it. This type of land devastation frequently follows after sheet erosion as a later stage of deterioration. When there is not enough vegeta-

tion to impede the run-off of storm water, the proportion of rain not absorbed by the soil finds its way downhill in a series of small torrents. A vicious circle is set up, because each channel is cut wider and deeper by every succeeding downpour, and the torrent tears soil from the sides and bed of the gully. Loss of soil is increased by the cutting back of each branch gully into the higher ground behind. Deeply gullied 'bad lands' are to be seen in many parts of India whenever the level of the land surface is at all high above the bed level of nearby rivers.



(Chart showing how soil erosion affects the general public as well as the farmer.)

The Jumna basin provides one of the finest examples of gully or ravine formation in the world. In many parts the vegetation on the neighbouring lands after centuries of abuse is of a very poor description and the rainfall flows away with great rapidity thereby increasing the volume and the violence of the torrents and leaving their beds dry after a few hours of the storm. The accumulated effect of this flood and scouring in a hard Kanker soil has resulted in the banks of the Jumna and the Chambal being violently eroded during the last few hundred years with a corresponding sinking of the water level.

A rough calculation has shown that the total soil erosion of the Jumna-Chambal basin is equivalent to the removal of

12 cusecs or ½ ton of soil per second day and night without stopping for the last 1,000 years.

Both sheet and gully erosion are caused by water action but another form of erosion results from wind action. Open treeless plains of dry light soil are particularly susceptible when the natural grass cover is destroyed by ploughing or heavy grazing, for the exposed soil can then be whipped up and carried away by strong winds.

Ground thus disturbed develops a peculiar topography of low hummocky sand-hills on top of which deep-rooted bushes survive after all other vegetation has given up the unequal struggle. Actually India as a whole does not suffer from wind erosion to the extent that has occurred in the so-called 'dust bowl' of the middle Southern States of the United States of America, or in the inland livestock ranches of Australia or along the southern fringe of the Sahara. But in certain restricted areas in India it is a definite menace, for instance, just north of Campbellpur in the Attock district and along the Delhi-Lahore road near Doraha.

Widespread Effects of Erosion.

The harmful effect of these three forms of soil erosion go far beyond the removal of the valuable top-soil on which plants depend for their nourishment. One direct effect is of course gradual decline in crop yields which more than off-sets any gains brought about by seed selection and manuring. The direct effect in pastures and grazing lands is to reduce the capacity of land for carrying livestock, for good pasture may carry a cow per every two acres, but the eroded pasture land may not keep a cow properly on ten acres.

Erosion also has indirect results, of which the most important for us in India is the dumping of large quantities of sand in the river-beds so that the bed must inevitably be raised and thus aggravate the effect of floods.

Another effect is to increase the severity of the intervening drought periods. This is because each small stream in the foothills discharges perhaps 80 or even 90% of heavy storms within an hour or so, and only a very small part of the rain soaks in the bare ground.

Apart from the rivers therefore the level of the water-table underground is apt to shrink because the amount of percolation or seepage through the soil into the underlying rocks and subsoil is less. Springs and wells are fed by reserves of water stored underground, but these reserves dwindle because eroded soil will not allow rain to penetrate underground, so that wells dry up, springs are reduced to a trickle, and rivers that once flowed all the year round now fail in the dry period.

Aside from the destruction above mentioned, erosion carries with it consequences of vast importance to the permanence of investments of large sums of money in navigation, power, municipal water supply and irrigation developments.

Deforestation and Soil Erosion.

It is admitted by all authorities on erosion that one of the greatest calamities which have overtaken mankind has been the destruction of the forest and the consequent erosion of the land surface. This has already destroyed the fertility of many lands and is at the present day exercising a great influence on the destiny of the people. Deforestation and soil erosion not only intensify floods and reduce the cold weather discharges of surplus streams but they threaten the sub-soil water supply and impoverish the soil and reduce the output of agriculture. In fact, these two demons threaten the very basis of civilization and of human life.

Erosion results from the misuse of the surface covering of the earth, whether it be by the destruction of the forest which covered it, by the misuse of arable or pasture land, by bad methods of cultivation, by burning or by over-grazing.

There is sufficient evidence to show that India is faced with the very grave danger of her river catchments being denuded to such an extent as to increase floods during the periods of heavy rainfall, decrease river supplies for irrigation and navigation during the dry season, increase siltation of the rivers, and throw large areas out of cultivation.

America is now fully alive to the disaster which threatens her and has even formed a special department of engineers to deal with erosion while her foresters are actively fighting deforestation.

There are many indications that in parts of India conditions are, at least, as bad and, sometimes, worse than they are in America. For instance, the Ganges carries to the sea eight times the quantity of silt carried by the Mississippi and that from a catchment area less than one-third the size.

It is not without significance that the highest recorded flood in the Ganges occurred in 1924 and the lowest record of winter discharge occurred in 1929. Records of the Ganges for over 100 years are available and this period is long enough to exclude all seasonal cycles.

American Research.

American research has found that during the years 1935-37, the rate of run-off from completely denuded lands, such as is only too common on the banks of some of our rivers, such as the Jumna and the Chambal, is twenty times greater than it

is from preserved forests. During one month of the flood season in Southern California a watershed, which had been burnt out 4 years previously, was denuded of 120,000 cubic yards of top soil or a depth of 1·4 inches per square mile. On a similar watershed burnt out 19 years previously, the denudation rate was one-tenth of this while in a watershed fully protected for the last fifty years the same rainfall only gave a denudation rate of one-thirtieth of this.

The fertility of the soil lies in its top crust and the removal of 1·5 inches of the surface soil which Nature takes a long time to create, amounts almost to a disaster. The unproductiveness of newly exposed sub-soil is well known and one might almost say that once the surface has been destroyed, fertility has gone for ever as far as the present generation is concerned. It seems quite reasonable to suppose that one of the most important factors contributing to the low crop yield in India is erosion by wind due to the absence of wind breaks.

Examples of Damage.

It is generally known that there are extensive waste and ravine lands in Agra, Muttra, Etawah and the adjoining districts. The ravines of the Jumna and the Chambal river form a practically compact mass the extreme length of which is 70 miles and the width about 13 miles in the centre. It is estimated that in the Etawah district alone there are about 120,000 acres of ravine land and there are large ravine areas in Agra, Muttra, Jalaun and other districts.

The Description of Ravines.

The banks of the Jumna and its tributaries are now so completely drained that the greater part of the area has become almost destitute of vegetation. Cultivation beyond this desert belt is precarious even in years of normal rainfall and the presence of these ravines renders irrigation impossible. Throughout the whole extension of this ravine land no water is to be found except in deep wells and in the main rivers. The dry belt is increasing in extent, as the ravines eat into the flat lands at the heads every year. With the hardening effect of the tread of cattle and rapid drainage the monsoon rains penetrate to a depth of only a few inches and this quickly dries up leaving a soil almost destitute of moisture down to the water table 100 feet or more below. It has been found that occasional scattered trees now found are of great age which have continued to reproduce themselves by coppice shoots and their root-systems have kept pace with the sinking of the water level, drawing up their necessary moisture from great depths. Natural reproduction invariably dies down as soon as the rains cease. The

natural vegetation of the ravine land has been destroyed by uncontrolled cultivation wherever the soil is fit for this, and by uncontrolled grazing, reckless destruction and by fires elsewhere. Large areas are now almost treeless but the original natural vegetation was undoubtedly forest and is still forest except in Kanker and Usar soils. The vegetation consists of small trees, thorny bushes and grass.

The Panjab Siwaliks.

Some of the worst erosion is evident in the Panjab Siwaliks, a range of hills skirting the Himalayas where the hill grazier has accompanied or followed the wood-cutter and effectively denuded the soil of its protective plant cover. In many places damage is not confined to the eroded slopes, further destruction being caused by torrents (chos) formed by gully erosion that sweep down the slopes during the monsoon. The cho is characterized by the steepness of its gradient and the violence and irregularity of its discharge. The torrent carries much suspended material which is deposited on the less steep lower slopes in a characteristic detrital cone which continually increases in radius and width. The chos debouching on to the cultivated sandy plains silt up the original drainage channels formed when hill erosion started, and the floods are forced out over wide areas. The floods subside as suddenly as they start, and all the water is lost to the land.

There is evidence that a hundred years ago the chos ran between well defined banks, and in some places perennial streams that could be used for irrigation issued from the hills. To-day, floods are the only source of water. Much of the subsequent erosion has been due to intensified exploitation that occurred when British rule secured some measure of prosperity and security. Reclamation might possibly be effected by closure of the land so that first grass, and then forest, could be re-established, but all the land is required to support the people, who have the right to use it, and the authorities have a natural aversion to interfering with jealously held rights. A drastic reduction in the surplus grazing animals is indispensable before any conservation programme can become effective.

Necessity for Control.

Accelerated soil erosion and its control presents the country with a physical land crisis of enormous importance to the continuing welfare of agriculture in particular and the entire social structure in general. Moreover, beyond the most acute crisis of the whole land problem, there exists the physical fact that there can be no permanent cure of floods or prevention of stream and reservoir silting until run-off is better controlled,

all the way from the crust of ridges down across the watersheds where floods originate and silt loads are picked up, on to the very channelways of streams, which have limitations upon their carrying capacity.

Control of erosion is the first and the most essential step in the direction of correct land utilization. It must be performed if the country is to avoid early arrival at an inconceivably bad land situation. The United States of America and the Union of South Africa have reached the same conclusion and are now engaged in a fight against erosion in their country. The Italian Government is carrying out an enormous land reclamation and conservation programme. Japan for many years has been spending many times the value of numerous critically eroding areas in order to protect indispensable valley lands from the erosional *débris* issuing from such sore spots. There is no reason to assume that India can better afford to neglect this gigantic problem of waning soil productivity than any other country.

FORESTS.

One of the most valuable assets of India is her forests both from the point of view of material wealth they represent and their incalculable value to livestock and agriculture, providing food and giving natural protection against floods and dust storms. Their beneficial influence on climate, on the conservation of the water supply, on the flow of streams and rivers and the prevention of the erosion of soil needs no emphasis.

To realize how important it is to retain the natural protection afforded by forests, one has only to look round at other countries and to see how large areas of land unsuited for permanent cultivation which were alienated from forests and made into farms have now been abandoned to waste and desolation and in others how forest denudation has led to flooding and dust-storms which have brought widespread destruction and misery in their trail.

With the steady growth year by year of knowledge of the importance of the part played by forests in the prosperity of countries, particularly an agricultural land like India, the problem has become of national interest.

The character of the forests in India is largely governed by rainfall and elevation. Where the rainfall is heavy evergreen forests are found. Under a less copious rainfall deciduous forests appear, containing teak, sal, and a great variety of other valuable trees. Under a still smaller rainfall the vegetation becomes sparse, containing acacias, tamarind, etc. In the Himalayas, sub-tropical to arctic conditions are found, and the forests contain according to elevation, pines, firs, deodars, oaks, chestnuts, etc. It has been the experience of all countries

that the natural processes of growth and reproduction by which forests are kept alive are incapable of keeping pace with man's destructiveness, hence it is necessary to take special measures in the ultimate interests of the country to preserve its forests from reckless destruction.

Forest Influences.

It you read history, you are bound to believe in the prosperity of the ancient kingdoms, and if you compare their ancient grandeur with their present decay, and their ancient wealth with the amount produced to-day, you can only be driven to one conclusion, and that is that the present decay of these countries is very largely due to the deterioration of the moisture that lies in the earth Now, just imagine for a moment, what has happened to Persia. Take the example of the palace of the King of Kings, Darius, who at one time reigned practically over the whole eastern world. Can you imagine a man occupying his position, building his palace in the desert? But to-day, if you see the ruins of the palace of Darius in Susa, they stand in an uninhabited wilderness. Mesopotamia, which for generations produced all the revenues of Persia by which that country was able to wage wars against the Romans, has degenerated into a dreary waste and the hanging gardens of Babylon are a rubbish heap. No doubt the degradation of Babylon was partly due to the destruction of the irrigation works by the invasion of the Mongols, but already at that time, the irrigation system of Mesopotamia was in a state of decay on account of the destruction of the forests on the hills, and the bad regime of the Tigris and Euphrates which supplied the water for the finest irrigation system in the world, a vast system with which the Panjab at the present day cannot compare. The same history has been repeated all over the world. In Greece, Anatolia and Spain, the destruction of the forests has seriously interfered with their climate, with their cultivation, and with the moisture content of their soil. So much has this been the case in ancient history that it has been stated that deforestation, by the lowering of the moisture content of the soil, thus decreasing the water supplies of the country, has done more damage than any war, and has resulted in the destruction of the greatest empires.

Utility of Forests.

The history of modern civilization is founded upon wood. Despite the increased use of iron and steel and their replacement of wood for many purposes it is a proved fact that the consumption of wood per head of population has been steadily increasing, unless limited by supplies, in all countries in proportion as the material prosperity of the people has increased.

In Europe and America the consumption of wood *per capita* is over 20 cubic feet; in India it is under 2 cubic feet. Prosperity involves increased wood consumption and to supply the ever-growing requirements of the people is one of the most important of the functions of the forests. The great mass of the population of India are not townsmen but agriculturists who live in the country, and those of them who are fortunate enough to live in the vicinities of forests know that the forests mean to them much more than the mere production of timber and that the success of their cultivation of field crops is intimately bound up with the existence of the forests. A supply of firewood is one of the most essential needs of the people, and where there are no forests from which firewood can be obtained the people have been driven to burn cowdung which should have been used to fertilize their fields. There are innumerable cases where the destruction of forests have led to the burning of cowdung with serious adverse results on the cultivation of crops. But apart from yielding firewood and poles for building houses the forests yield many other kinds of produce which the agriculturist wants. They yield him timber for making his ploughs and other agricultural implements, bamboos for fencing and other purposes, thatching grass, grazing for his cattle, edible fruits and flowers which help him to live more especially in times of famine, fibres for making ropes, medicines for the sick, and many other articles.

There are numerous indirect benefits conferred by forests whose importance is not readily understood.

Firstly, forests increase the relative humidity of the air, reduce evaporation, and maintain a more continuous degree of moisture in the soil. They also tend to increase precipitation of moisture. These effects are important from the agricultural point of view in a hot dry climate such as is prevalent over the most part of India.

Secondly, forests assist in regulating the water supply by reducing the violence of floods and by rendering the flow of water in rivers more continuous. They further assist in preventing erosion. On denuded soils the rainfall rushes off the surface in torrents which gather in volume and sweep away the fertile top soil of the land. On forest-covered areas the rain-water is held up by the crowns and roots of the trees and the more spongy forest soil, with the result that it percolates more slowly into the ground and emerges in the form of springs which supply the rivers more continuously with water. In areas where deforestation has been rapidly proceeding many of the streams which used to run all the year round have now dried up and this has had a bad effect on field crop cultivation. Innumerable examples of the serious effects of forest destruction on the fertility of the soil and water supply could be quoted from all over India. This valuable effect which

forests have in reducing the effect of erosion and floods is not, however, confined to the areas in which the forests are situated. The disastrous floods in the plains have been due to the destruction of the forests in the river watershed. Such floods tend to get greater and greater each year as the destruction of forests in the hill areas in which its tributaries have their source proceeds and unless this progressive destruction of forests is checked the time may one day come when still more disastrous effects of flood will be experienced.

Thirdly, forests reduce the velocity of wind and protect adjoining fields against hot dry winds. They afford shelter to cattle and generally reduce the temperature of the air and render the climate more equable.

Fourthly, forests increase the artistic beauty of the country and exercise a restful effect on the human mind, thus assisting in furthering the happiness of the people.

Forest and Floods.

It has been often stated that a forest cover in a drainage basin materially reduces floods but forested areas are not free from the hazard of flood damage. Although the effect of forests upon run-off has often been overstated their effectiveness should not be depreciated.

Adequate flood protection is largely dependent upon engineering structures but the forest cover should be considered as a supplementary protective measure. A closely forested area with its absorptive leaf-litter delays run-off somewhat and gives greater seasonal uniformity to the discharge of the streams. This slight retardation of run-off may serve to reduce floods provided the subsequent rains are delayed a sufficient length of time to permit the lowering of the water table and a drying out of the litter. If the absorptive capacity of both the litter and the soil is reduced because of saturation heavy downpours of rain will cause floods. Probably the most important effect of the forest cover is not in its effect upon surface run-off but upon its protection of the soil, which in rugged areas is susceptible of removal, and when both the forest cover and the absorptive topsoil have been removed, all rains, no matter what their spacing, yield rapid run-off. These indirect results are of major importance in the prevention of floods and in the maintenance of reservoir capacity whether the reservoirs be used for flood prevention or for other purposes.

Deforestation in India.

There can be little doubt that there were forests stretched over the greater part of India. In the Vedas, the earliest religious writings of the Hindus, in the epic poems of the Ramayan and the Mahabharat, references are made to dark, dense forest

areas situated in the Gangetic Plain, now a vast expanse of cultivation and for a thousand miles or more devoid of forest growth. Similarly the records of the wanderings of Chinese pilgrims (about 600 B.C.) frequently speak of miles and miles of very dense forests in the now almost treeless districts of Gorakhpur and Western Bengal. As late as the sixteenth century the Moghul Emperor Baber hunted tiger and other big animals of the forests along the Jumna river, in areas which have now become barren ravine deserts of stunted thorny bushes.

In the turbulent days of early Indian history with the rise and fall of dynasties and powers, the areas of forest fluctuated, shrinking to make place for cultivation with the advent of a strong ruler, increasing again with the collapse of central power, or when wars, pestilence and famines reduced the density and pressure of population. Thus we still find ruined and long forgotten cities in some parts of Indian forests. With the advent of the British rule in India, resulting in a great increase of population, with the attendant demand for timber for agricultural implements, constructional purposes, etc., a fierce onslaught was commenced on the forest areas and by the middle of the nineteenth century all traces of primeval forest in the Gangetic Plain disappear except in the mountainous regions. Thus the destruction of the forest area, or rather the diminution in the area of the forests within the boundaries of India, has been going on at a very great rate during the last 150 years. To give you an instance, when the Emperor Jehangir built the castle of Nurpur for his Queen, Nur Jehan, the Light of the World, he writes in his memoirs that forest was so thick that a bird could hardly spread its wings. But if you go to that place to-day, you will see nothing but a denuded hill country, with hardly more than a few tufts of grass and thorn bush on which a few goats eke out a miserable existence. All that has happened in a period of not more than three hundred years; in that time the dense forest which clothed the outer Himalayas has been reduced to a negligible amount.

Due to the reckless extermination of forests by man or through excessive grazing, fires or over-cultivation, the area covered by forests in the United Provinces has been reduced to 4% of the total area of the province and is confined almost entirely to the hills and submontane region. This in itself by all standards is inadequate to meet the diverse demands of a progressive country as it has been estimated that about 20% of the area of a country should be covered by forests.

Necessity of Forest Protection.

There are two main reasons why such protection is necessary. Firstly, forests require protection from man. It is a common

failing in human nature that whenever any product is found in abundance its use is abused without thought for the future. The steady destruction of forests which has taken place in the old and new world is a striking example of this attitude on the part of man. The great Indian epics tell of the mighty forests which used to exist in the Gangetic Plain. At the present day there are only remnants of forests left which are confined to the hilly tracts of the country, and over most of the plains the people are put to hardships as they cannot get the forest produce on the supply of which the success of their cultivation depends. The reclamation of forest land by bringing it under the plough is a sign of agricultural progress as the people must have food to live and the greater the area under cultivation the better. But there are large areas of forest land which have been cleared for cultivation, which should never have been cleared as the soil is poor and incapable of supporting field crops year after year. Good forests can be grown on land which is poor from the agricultural point of view, and on such poor soils forests should be retained because they are more valuable than field crops. The practice of shifting cultivation under which forest areas are cleared and burnt, cultivated for two or three years, and then abandoned, has been responsible for destroying large areas of forests.

Apart from the clearing of forest land for purposes of cultivation there is another factor which has been responsible for the destruction of numerous forest areas in the country, and that is that, left to himself the villager takes no care of his forests. He hacks down the trees indiscriminately and allows his cattle and goats to graze all over the forest thereby preventing any new trees from growing up to take the place of those he has removed. In how many thousands of villages can you see areas of barren waste land which formerly were covered with useful forest and which now do not yield even a scanty supply of grass? It is thus sufficiently evident that forests must be protected from the thoughtless acts of ignorant villagers who would otherwise destroy the forests with dire consequences for future generations.

Forest Conservation.

Forest conservation is a field of vast significance in Indian life. The services which forests can perform are numerous and their influence far-reaching. Moreover, the renewable character of forests makes for a very practical phase of conservation. With sufficient forethought, the country's resources can be kept at a level more nearly commensurate with its needs for wood products and other forest services, and, at the same time, much of the land which is now unproductive but suited to growing trees may be put to use.

Water Resources.

One cannot imagine man separated from water any more than one can imagine him separated from land. Water is an essential part of his being. He uses it in innumerable ways and because in areas of dense population he has been favoured with it, frequently he spends it recklessly, thinks of it as he thinks of air as an unlimited requisite of existence, and gives little heed to its value. In drier regions water is held of great value, and stringent laws governing its use are formulated.

The place of water in the lives of people in arid lands may be realized by the frequent rain ceremonies of the Hopi Indians and by the repeated references in the religious literatures of desert peoples, as the Bible and the Koran, to water as a blessing and to paradise as a place where there is abundant water.

Our water comes from precipitation, and the average rainfall for India is about 42 inches per year. This average will lead us easily to the total amount of water received by the country in one year but it tells nothing about the distribution.

The rainfall varies from almost nothing in the desert tracts of Rajputana to over 100 inches in the outer Himalaya and is profoundly affected by elevation and the distance from the sea. Most of the annual rainfall takes place in July, August and September during the summer monsoon; April and May are dry and intensely hot; the autumn is dry and in winter very little rain falls. Towards the north-west the rainfall decreases and the Panjab, formerly a desert, is now irrigated by a network of canals which take their origin from the rivers of the Himalayas.

In regions of scant water supply, conflicts are likely to arise over water rights, and frequently in densely settled regions there must be a choice between its various uses. One arrangement of the uses of water in order of influence or importance is as follows:—

1. Atmospheric moisture indispensable to organic life.
2. Drinking water for man.
3. Water used in agriculture and animal husbandry.
4. Water as a habitat of fish and sea-food.
5. Water used for generation of power.
6. Water used for mechanical and chemical processes in industry.
7. Water as a means for transportation.
8. Water as a medium for the removal and purification of waste.
9. Water as a recreational asset.
10. Water as a determinant of political boundaries.
11. Water used as ice.

India, for the manifold uses of water, must depend upon its rainfall. The 42 inches of annual rainfall cannot suffice

for all of them. About one-half of the rainfall is evaporated and goes back into the atmosphere as water vapour; about one-third of it forms the run-off, draining by streams and rivers to the sea. This is the visible water supply, and the greater percentage of the use in the above list arises from this portion of the water. One-sixth of the rainfall sinks into the ground and forms ground water: this is a less well-known but very important reservoir of water which acts as a stabilizer of lake levels and stream flow and a source of water supply for the plant growth.

The problem of the manipulation of the enormous amount of water which falls in India varies with the humidity or the aridity of the area. Evaporation, run-off and ground soakage are not uniform, and unwise practices may increase run-off to a danger point and destroy the balance set up by natural agencies. Among the many problems of water are the control of floods which, for example, have caused great losses of life and property in the eastern Gangetic Plain; the control of low water stages which have hindered navigation, as on the Ganges and the Brahmaputra rivers, or have caused losses of crops; its use for navigation, power, water supply for cities and towns, and the removal of refuse from houses and factories; the erosive tendencies of rain and streams; the silting of streams and consequent deposition when stream flow decreases; its use for irrigation; the maintenance of the ground water supply and the stabilization of the water table, and the use of water as a recreational appeal. A water policy of the country should be so established as to yield the greatest benefit possible from our water resources and be so regulated as to serve the greatest need. At all events, one needs take the stand that water is a highly valuable source, too precious to be wasted.

Importance of Water for Domestic Purposes.

Water is one of mankind's most essential needs. Primitive settlements were located around springs and water-courses, and when the water failed the people were driven from their homes. Palmyra, once a city of possibly more than 150,000 people, vying with Damascus for the trade between Egypt and Babylon and reaching great prominence under the reign of Queen Zenobia, consists to-day of a few ruins in a desert landscape while Damascus still exists. Both were oasis cities, but the drying up of the oasis at Palmyra spelled its doom. Later people learnt how to build aqueducts and transport water from distant springs and rivers. When gold was discovered in the Australian desert in 1892, and the towns of Kalgoorlie and Coolgardie were founded, the district was practically waterless. For a while the railway transported water to the towns at a cost of about Rs.15,000 a day. In 1903, a water line was

completed from the Darling Range, 350 miles away, and a delivery of 8,000,000 gallons daily resulted. So long are the pipes that they contain a month's supply of water; in other words, the water takes one month in travelling from Mundaring to Kalgoorlie.

Residents of the Indo-Gangetic Plain have not really appreciated the value of water as the dwellers in more arid regions have. The idea that there was an ample supply has been passed on from generation to generation. To-day it is necessary to combat the idea and treat water as a natural resource of limited though perhaps inexhaustible amount which must be conserved so that the supply at any one time may be adequate for our needs and particularly so that its misuse may not be a burden to future generations.

Sources of Water Supply.

Cities and towns in India obtain their water supply from many sources—lakes, tanks, wells, springs, tube-wells, and streams. Most rural towns and many urban localities depend on ground water for their domestic supply, and this comes to them in part through springs but largely through ordinary wells. In every rainfall where there is a surface mantle over the rocks a certain percentage of the water is absorbed by the soil (estimated average about 16%). This forms ground water. Its upper surface is known as the water table. The amount of ground water is much greater than is commonly supposed. It has been said that there is enough water under ground so that, if it were brought to the surface, it would form a layer probably 500 to 1,000 feet deep. The depth of the water table varies; in swamps the water table reaches to the surface, and in arid areas it may lie a hundred feet below the surface. Frequently, in the Gangetic Plain, water is struck before one digs to 25–30 feet. The water table depth in any single locality varies with the rainfall. A long period of drought takes a serious toll of the ground water, and the water table may be so lowered that it falls below the level of the well bottoms and the wells become dry. If the drain is not heavy the water table is generally brought back to its normal level by succeeding falls of rain. An extended drought, however, may bring serious damage by killing off the vegetable cover and subjecting the soil to wind and later rain erosion. In some localities, the water table has been lowered beyond the level of efficiency by stripping the vegetation cover, as in excessive deforestation, and in the processes of extensive cultivation, soil erosion, and ditching. For example, it is estimated somewhat roughly that the water table over large areas in India has been lowered by 10 to 20 feet by these methods. As an extreme example may be quoted the serious reduction in the base level of the Jumna River

where flooding and scouring has lowered its bed at Etawah 60 feet in the last five centuries with a corresponding fall in the spring level. The cold weather level of the river is often 120–200 feet below the surrounding country. The effect of this upon the ground water supplies is obvious.

Irrigation.

The arid and semi-arid regions of India like Sind, Rajputana and the south-west Panjab which are practically rainless have largely been rendered habitable and their latent resources made available to man by the use of water for livestock subsistence and irrigation. Water, a vital resource in any environment, assumes extraordinary significance in regions of less rainfall. In the arid and semi-arid regions of India, the conservancy of water becomes of permanent importance.

The chief characteristics of the Indian rainfall are its unequal distribution throughout the country, seasonal irregularity of precipitation and liability to failure or partial deficiency in many tracts. But, within individual tracts, remarkably wide variations in total annual rainfall are found. Such tracts include practically the whole of the Panjab and North-West Frontier Province, the United Provinces, except the sub-mountain regions, Sind, a large portion of Bihar, most of the Madras and Bombay Presidencies, omitting the coastal belts, and portions of the Central Provinces. The concentration of the principal rainfall in less than a third of the year places a very definite limit on the agriculture of the country. Thus our agriculture cannot afford to depend exclusively on rainfall and it becomes necessary to provide the agriculturist with suitable irrigation facilities.

The advantages of irrigation are numerous, the principal one being an increase in the yield of crops, the successful introduction of a stable agriculture in arid and precarious tracts, protection from and insurance against famines and scarcity and larger railway profits in agricultural provinces. The Indian canal system is by far the largest in the world. Of the total cultivated area of 280 million acres, no less than 60 million are irrigated from one source or another.

Greater demand for Water.

In view of the rapid increase in India's population and consequent increase of pressure on land the demand for more water for irrigation and for better distribution of the existing supplies becomes annually more insistent.

Water Power and its Conservation.

IMPORTANCE OF POWER: Mechanical power is the heart of modern civilization. Until means of mechanical power were developed man was unable to gain any definite control over the elements. The power-driven machine and its accompanying division of labour have almost entirely replaced the self-reliant workman of former decades. Man's welfare and comfort depend upon a continued and uninterrupted supply of power. Power is as essential a part of the necessities of modern life as are food, clothing, and homes. Indeed, without the use of mechanical power man's necessities and luxuries would be limited to the products of his immediate locale. The use of power allows him to live where he desires, to have his wants carried to his home, and to be transported to and from his work.

Sources of Power.

The principal sources of power available in India are coal, wood-fuel, oil, wind and water. Coal is India's most important mineral and India produces more coal than any other part of the British Empire with the exception of the United Kingdom. Most of the coal raised in India comes from Bengal, Bihar and Orissa (the Gondwana coal-fields). Outside these provinces, coal is obtained from Hyderabad State, Central Provinces, Assam, the Panjab and Baluchistan. Rajputana, Bikaner and Central India also contribute a small amount to the total coal supplies of India. Indian coal is thus very unevenly distributed, the deficiency being especially marked in the case of the peninsula. The absence of coal supplies coupled with the high cost of railway transport acted as a great handicap to the growth of industries and this had to be overcome partially by the use of hydro-electric power. The utility of forests as supplier of wood-fuel has already been referred. Many of the Indian forests are, however, confined to hilly tracts from which transport is a matter of great difficulty and expense. Moreover, it is doubtful whether the supply of wood-fuel could keep pace with the demand for it for industrial purposes. The position with regard to India's oil resources has completely changed due to the separation from India of Burma from which nine-tenths of the indigenous petroleum was obtained. As the possibility of the oil-bearing areas in Baluchistan, the Panjab, Assam, etc., must still be regarded as problematical, it would be unwise to place much reliance on this particular form of power.

Water Power.

As is evident the situation in India with regard to the supply of coal, wood-fuel or oil for purposes of generation of power is not quite so favourable as might be desired. There

are, however, fair prospects for the development of water power resources at its command. These have been limited so far on account of the seasonal character of the rainfall making costly storage works indispensable. In spite of this limitation, there are many potential possibilities of tremendous importance and within recent years considerable attention has been given to large hydro-electric power schemes. It is hoped that these schemes will not only serve the purpose of supplying power to the industries but also of extending the irrigation facilities in India.

Electricity for Villages.

We may even be tempted to dream of a time when every village within a reasonable distance from a hydro-electric power station will receive its supply of electric current to help the development of rural industries and increase the amenities of rural life. A start has been made and development on these lines has been undertaken extensively in the United Provinces. The power available at falls on perennial irrigation canals has been harnessed and converted into electrical energy. The power so generated is being utilized for commercial, domestic and agricultural purposes. But on the whole there are great obstacles in the path of realization of all these bright visions. The initial expense of most of the hydro-electric schemes in India is heavy. The rainfall being seasonal, costly storage constructions are necessary and the expenditure thus incurred makes it difficult to supply power sufficiently cheap. Whether science will be able to remove this difficulty, the future alone can show.

Floods and Flood Control.

Rivers come into existence as a result of precipitation falling upon the earth's surface, and have as their chief function the drainage of the excess waters to the sea. The lands receive their precipitation at very irregular intervals, and as a result the river with a uniform discharge does not exist. If all precipitation could be absorbed into the earth to become a part of the ground water and then discharged more or less evenly the streams probably could be confined to their channels. But an important proportion of the precipitation never becomes a part of the ground water but flows quickly to the water-courses, swelling the streams beyond their constraining banks. The placid stream fed largely by underground waters becomes in times of flood a raging torrent. With its capacity and its competency greatly increased, the river in flood becomes a powerful agent of destruction. Streams vary greatly in their capacity for destruction, but none is without its flood problem.

The fertile alluvial lands of the Nile, the Tigris-Euphrates, the Hwang Ho, and the Mississippi, the creation of their

respective rivers are repeatedly inundated, bringing death to millions and destruction to the works of man. The great rivers are, at the same time, the giver and destroyer of life and property. Smaller streams suffer from recurring floods, and the damage done is locally very great. The flood problem may be said to have its beginning when waters derived from run-off and underground sources spread beyond the restricting channel of the stream.

Flood Destruction.

The predisposition of the people to pre-empt the rich riverine lands for both agricultural, industrial and commercial purposes subjects them to the hazards of the recurring floods. Many of our large cities such as Delhi, Agra, Cawnpore, Lucknow, Benares and Patna were founded upon rivers when the water-courses were the principal highways of commerce. The use of lowlands for industrial and commercial purposes has caused excessive damage at times of flood, due both to the destruction of property and the suspension of business. Lands once used for private purposes are not easily relinquished, for the owners, especially if individual landholders, can hardly afford to abandon the properties to the use of the river. In such areas the recurring floods cause increased damage due to an increase in property values through the years. Urban areas subject to floods are abandoned only with great difficulty, for both industries seeking lowland values and people of the low-income class seeking low rentals are likely to locate on these cheaper lands along the rivers. Protection against floods is sought before abandonment is considered. If protective embankments prove adequate property values increase and the utilization of land is intensified. Then an unprecedented flood which breaks through the embankments causes great damage. The increased property damage in many cities is due to man's encroachment upon the river.

In agricultural areas the amount of damage depends upon the intensive economic use to which the land is subjected. The inundation of the crop lands may greatly reduce the yield or completely ruin the crop. The losses in rural areas are offset in part by the enrichment of the lands by the deposition of silts. The fertile topsoil eroded from the slope land within the drainage basin is deposited in part along the alluvial plains of the master stream and the major tributaries if they are aggrading streams. In some areas the spreading of coarse sand and gravels along a flood-plain may depreciate the value of the land for crops.

Causes of Floods.

Floods are results of many conditions working singly or in combination. Usually no single cause can be assigned the

whole responsibility. The immediate cause of most floods, however, is the excessive run-off from precipitation of high intensity, though many other conditions may be necessary to cause a great flood.

Flood Control.

To escape from the danger of floods various control measures either singly or in combination have been utilized to provide the necessary protection. Probably one of the earliest methods used to escape from floods was to evacuate the area at the first warnings of impending danger. Flight to safe areas could hardly be interpreted as flood protection but it did mean the protection of life and a limited amount of property. This method is still used when other methods of protection fail. Throughout the history of civilized man the fertile alluvial lowlands have been preferred areas of habitation; and, as high water menaced periodically the homes of the people the protecting dyke or embankment became one of the first methods of defence against floods. In other countries the flood problems are being attacked by various methods. One of the simplest and most individual methods of flood protection is channel improvement. Embankments are very commonly associated with other local preventive measures used along the smaller as well as the major streams. Further, the problem of flood protection may be partially solved by the use of preventive works in the head stream area of a drainage basin. Under certain conditions these storage reservoirs not only provide a solution to flood problems but may be used for other purposes such as water supply, power, irrigation, etc.

The Responsibility for Flood Control.

The control of floods is a responsibility which extends beyond the limits of the inundated area. Floods have no respect for political jurisdictions, just as political boundaries show little relation to hydrographic boundaries. Since flooded areas seldom coincide precisely with political areas the existing minor civil divisions such as tahsils and districts are unable individually to cope with the flood problem.

Individual Responsibility.

The flood problem begins with the formation of a tiny rivulet in the farmer's field. Its control is both a personal and a social responsibility. His personal interest is not confined to the hazard of floods on his farm but to the associated loss of soil as the run-off gathers into rivulets which converge into larger and more devastating streams, producing both water and soil damage.

The individual landowner, though he may have a humanitarian interest in the flood hazards of the drainage basin in which he lives, can do little towards the solution of the problem, especially if he lives beside a large stream. In rural areas when streams are small, individual farms may, by channel improvements and the construction of embankments, give protection to their low-lying lands. The clearing of a stream channel of driftwood, trees, and other obstructions may so facilitate the flow during the time of high water that the channel is widened, thus increasing its capacity.

Imperceptibly the personal responsibility of many individuals enlarges to a regional responsibility co-extensive with each important drainage basin.

Regional Aspects of Flood Control.

Planning for the best use of water resources is essentially a regional responsibility, the region being coincident with the drainage basin of the streams concerned. This concept of the planning region cannot be adhered to rigidly, for the transmission of water power in the form of electricity and the distribution of water for irrigation and municipal purposes extend far beyond the limits of drainage basin, and require a modification of the hydrographic region to include adjacent areas which constitute the peripheral sections of an economic region.

The problem of flood control, however, is rather strictly confined to the drainage basin. So long as control measures involve only riverine works the plan would require the co-operation of riverside communities but as control is extended to include preventive measures the whole drainage basin should be organized into a unit. The obstacles which make difficult the realization of this ideal are many, and probably will stand in the way of a strictly regional organization based upon the hydrographic basin.

Responsibility of the Provinces and the Central Government.

Where a drainage basin lies entirely within a single province the responsibility of handling the many water problems lies on it. Flood problems which involve two or more provinces may require inter-provincial co-operation in order that a flood-control programme may be extended to all parts of the drainage basin. The co-operation should include not only an inter-provincial agreement but also a uniformity of laws to facilitate the work connected with flood control. The State's responsibility also extends to finance the operations. For such purposes excessive expenditures may be justified, but there should be a careful scrutiny of all flood-control plans to make certain that the benefits to be gained equal or exceed the cost of the protective works.

Conclusion.

In conclusion I would emphasize that soil erosion in India has become a matter of vital concern and demands immediate attention. The improvement and fertility of Indian soils is another important problem. Planning on a wide scale to maintain soil fertility is, therefore, of supreme importance to the country in her campaign of rural reconstruction. The rapid increase in population since British occupation has greatly intensified pressure on the land, caused the cultivation of much unsuitable ground and shortened the resting periods between cultivation that are frequently necessary for the stability of tropical soils. The human population of India is increasing at the rate of about 4 to 5 millions per annum. Much of this increase is occurring in the tract where nature in the first place provided easy conditions for human settlement, namely rainfall not too heavy for the ordinary farm crops, and natural grasslands in which cattle thrive. Therefore, much of the weight of this increasing population is falling upon the tension belt where grassland can persist only under reasonable treatment, and if once destroyed cannot reinstate itself as easily as it can under a slightly heavier or better distributed rainfall. Hence over very large tract of country natural grasslands have already disappeared and village livestock are dependent upon bush and tree growth for their day-to-day existence. The amount of erosion caused directly through over-cultivation and over-grazing has become a national menace.

The conservation of forests and water resources of India are also vitally connected with the problem of ever-increasing population of the country and require a sound planning.

We should, therefore, recognize that problems of conservation are vital to each and every citizen of the nation. To one who is alive to the significance and magnitude of the problem of providing posterity with the means of a richer and happier life the conservation of the natural resources and their economic exploitation will appear to be the only possible solution. The development and administration of conservation projects will demand the full time of a large staff of experts maintained by the State, and it is gratifying to note that the Imperial Council of Agricultural Research and Provincial Governments are directing their strenuous efforts towards the execution of such projects, yet much cannot be achieved without the cordial support and co-operation of all citizens whether they are developing natural resources which they own privately or developing resources on public lands. The spirit of conservation demands that we recognize limitations to our personal rights in the utilization of gifts made by nature and render best services in the execution of local, provincial and national projects of conservation.

SECTION OF BOTANY

President :—SHRI RANJAN, M.Sc. (Cantab.), DOCTEUR ÈS SCIENCES

Presidential Address

(*Delivered on Jan. 4, 1941*)

THE RESPIRATION OF PLANTS IN LIGHT

LADIES AND GENTLEMEN,

I am deeply sensible of the honour done to me by the invitation to preside over the section of Botany at this 28th Session of the Indian Science Congress. An honour like this is in itself a matter for gratification, but it becomes doubly welcome when the Congress happens to meet at Benares—the place of my birth and early education. I recall that fifteen years ago in this very city a great teacher and a kind friend, Professor R. S. Inamdar, occupied the presidential chair. Professor Inamdar was one of the founders of the School of Plant Physiology in India, and his memory as a Professor will for ever be cherished especially by his former pupils.

For the purpose of my address the Session at Benares is particularly opportune. Benares was and is the home of physiological research. The subject of my address which is on some physiological problems, though specialized, may perhaps interest a larger body of scientists.

THE THEORY OF PHOTOCHEMICAL ACTION

With the rapid advance of Science towards unravelling the mystery of light and bridging the gulf between light and matter, the subject of Photochemistry has, as rapidly, forged ahead. Invitro experiments have enabled us to get clearer conceptions of photosynthetic and photo-oxidative reactions. These reactions are, however, far more complicated in the living matter and my aim here will be to discuss whether or not photo-oxidations take place in the plants, as well, or, in other words, whether there is a 'Light respiration' as opposed to 'Dark respiration' in plants. But before we start on the problem itself let us briefly understand the general theory of photochemical action. Photochemical reactions are chemical reactions which are produced directly or indirectly by absorption of radiation. This was first propounded by Grotthus (1819) and, at a later date, independently by Draper (1841). Consider now a beam of light, composed of

various wavelengths, falling on a chemical molecule. Light consists of a series of periodic electro-magnetic disturbances of various periods of vibration. A molecule has also a certain period of vibration. Thus those light waves that have similar periods of vibration as the molecule will get absorbed and by so doing set up a resonant vibration in the molecule, which may reach an amplitude great enough to bring about a chemical change. Such changes may lead either to an increase of energy or to a decrease. A simple case of a former type of reaction is that of anthracene which, in light, polymerizes to di-anthracene and thereby the stored energy is increased. The assimilation of carbon by green plants is a case of complex reactions leading to an increase in energy. Photochemical reactions, however, resulting in the loss of energy may according to Weigert[40] be divided into (1) compound reactions and (2) catalytic reactions. In the case of the compound reactions the products of photochemical change are used up in another reaction. The photographic plate may serve as an example. By the action of light bromine is liberated from silver bromide thus forming an intermediate product. This then combines with the gelatine on the plate causing bromination of the gelatine. Respiration in plants, obviously, cannot come under this category, for in this case light is essential for bringing about the production of intermediate substances; it is not so in the respiratory process. On the other hand, there are numerous photochemical reactions which even in darkness, after a period of illumination, proceed at a speed greater than their thermal velocity. These show the phenomenon of 'After effect'. In such cases, in all probability, the increased quantum yield may be due to the formation of a catalyst. The well-known reaction of iodoform in chloroform, which liberates iodine in light and continues to do so even in darkness with a sufficient velocity which is, however, less than that in light will serve as an example. Such reactions will come under Weigert's second group, viz. catalytic reactions. All these reactions whether they be anabolic or catabolic must be preceded by an activation process. The ordinary vital reactions are slow for the simple reason that large numbers of molecules do not move with a very high velocity which is necessary for chemical reactions. Ordinarily, all the molecules do not move with such high velocities and thus the reaction goes on in darkness at a slow rate, but in light the molecules absorb radiant energy and thus increase their vibration velocity. According to the third law of dynamics, however, any reaction, that causes the diminution of free energy, must take place, for by so doing free energy is decreased. Thus after the vibration velocity increases, a reaction leading to the diminution of free energy takes place. Fig. 1 may serve to explain this point.

An unactivated molecule of $C_6H_{12}O_6$ will not oxidize to CO_2 and H_2O in the same manner as a ball kept on a roof will

not fall below. The ball has to be pushed to enable it to fall, so also the sugar has to be activated first before any katabolic reaction takes place. In both the cases there is a loss of energy.

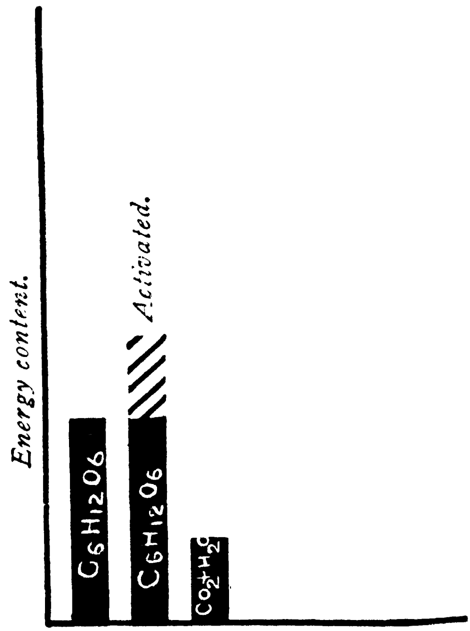


FIG. 1.

Thus in all cases of such reactions, even though there be a final loss of energy, intake of a specific quantity of energy must at first take place.

THE PRIMARY PHOTOCHEMICAL PROCESS

With the development of the modern method of research in photochemical reactions the rôle of the primary absorption process in gaseous reactions has been of great importance in discussing the mechanism of the total (primary and secondary) photochemical change.

In this connection the quantum theory of Stärk [36] and its subsequent development by Einstein [13] is of great importance. Einstein assumed that absorbed light energy in amount equal to $Nh\nu$ should bring to reaction ν molecules, provided the time interval between the absorption of an energy quantum by a molecule and its subsequent reaction was small in comparison with the mean life of activated molecules.

According to Bodenstein [5] the primary effect of the absorption of light is the ionization of the molecules, but this

has been found to be invalid. Later Warburg [37, 38] and Nernst [24] advanced the view that dissociation of the molecules occur as a result of the primary photochemical process.

The phenomenon of light absorption by both the atomic and molecular systems have recently been studied by Franck [14], Rollefson [34] and others and it has been argued that in the atomic system, the atom in question is excited to a higher energy level and the excitation energy is utilized in the secondary reaction in presence of other gas molecules.

Similarly, for atomically bound molecules, if the absorption lies in the continuous region then according to Franck the molecules will be dissociated into atoms and one of the atoms will be in the excited state and in the presence of some chemically reacting component the excited atom will react and bring about the net photochemical change.

Recently, Bhattacharya [3] has shown that the rôle of the primary absorption process is activation or may be atomization of the molecules which is but a physical change in the state of the molecules. The electronic energy absorbed is subsequently transformed into kinetic energy which makes the molecules more reactive with the result that the initial rate of secondary chemical reaction is accelerated. Bhattacharya has further shown that the temperature coefficient for the primary process in photochemical reaction is unity.

In brief, the exact position of the present idea about the primary absorption process in photochemical reaction is that the absorbed energy is responsible for the initial acceleration of the thermal reactions in light and that the photochemical reaction is the continued effect of this absorption process together with the secondary chemical changes which may set up chains.

With this preliminary talk on the present knowledge of photochemical reactions I shall now proceed to apply it in the case of plant respiration.

Historical review:

The earlier work on this branch of the subject is very scanty. It was Borodin [7] who discovered an indirect relation between light and respiration. He found that the respiration activity of leafy twigs gradually decreases in darkness. Bonnier and Mangin [6] showed that light has a direct effect on the respiratory mechanism. If plants are placed alternatively in light and darkness a retarding influence of light is noticed. This has no relation to carbon assimilation, for this effect is noticed even in plants without chlorophyll.

Maximov [23] finds that the effect of light upon *Aspergillus niger* varies with the age of the culture as also with the natue of the nutrient medium. Day [9] found 3% to 4% more respiration for barley in diffuse daylight.

· Spoehr [35] divides the light reactions into two classes direct and indirect. In the first, with which we are here concerned, light directly acts bringing about physico-chemical changes of certain physiologically important substances within the organism.

Warburg [38] finds that light has some photochemical effect on respiration. Working on yeast he finds that respiration is arrested by the presence of CO. But if a mixture of yeast and CO is exposed to light, respiration re-starts. This is due to the dissociation in light of the CO which is bound to the Fe of the respiratory ferment.

Recently, De Boer [10] working critically with fungi finds no effect of light on respiration. This, as subsequently discussed, may be due to the inability of the colourless fungi to absorb the necessary radiation. For, to cause a primary photochemical process to take place light must be absorbed in the system.

It should also be pointed out, that it is not necessarily true, that chemical reaction must follow absorption. For instance if radiations of long wavelengths are absorbed the quantum of energy may be too small to effect a reaction. It is possible that colourless fungi either cannot absorb radiations or absorb such radiations as are incapable of producing any chemical reactions.

The problem of the effect of light on respiration has been investigated in our laboratory from five different angles, viz.:—

(1) The respiration of non-green but coloured leaves and flowers in light.
(2) The respiration of colourless organs, like roots, in light.
(3) The respiration of green leaves in light and the after effect.
(4) The effect of temperature and light upon respiration.
(5) And finally, in view of our knowledge of respiration in light, the study of the real assimilation rate of carbon. We shall discuss these one by one and then try to arrive at some definite conclusions.

The floating respiration :

Most plants, respiring in darkness, show a slow fall in their respiration rate, when brought from light to darkness. This unstable transitory phase is noticed only at the first phase of respiration and is called the 'floating' respiration by Blackman [4]; while the low steady rate of respiration reached after the floating part is the 'protoplasmic' respiration.

That starvation is definitely not responsible for the fall in the floating part of the respiration curve, is shown by Ranjan [29] for Mangifera and Eugenia leaves. The leaves of these plants possess enough food material in reserve to maintain a high rate of respiration for weeks.

Physiological starvation, however, which can be brought about by high temperature, due to the shifting of the starch ⇌ sugar balance so that the available sugar decreases, is well known, but the laboratory temperature of 35°C. at which the experiments were conducted was not higher than the temperature in the open in the tropics. Thus physiological starvation too cannot explain the fall in the respiration rate.

In the light of the subsequent results, herein described, one is forced to conclude that this fall in the respiration rate at the 'floating part' is due to the direct effect of the absence of solar radiations on plant respiration.

The respiration of non-green but coloured leaves and flowers:

Work on the colourless leaves of *Croton* by Ranjan [29] shows, that during the first phase of respiration in darkness a slow fall o the typical floating type is noticed. When these leaves were illuminated from a 1,000 W. lamp, kept at a distance of one foot, the respiration rate actually showed a distinct increase throughout the period that the leaf was in light (Fig. 2).

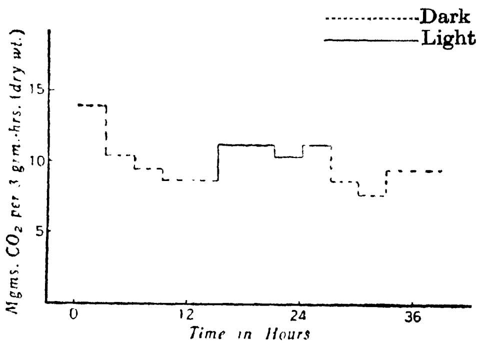


FIG. 2.

On removing the source of light the respiration rate fell off to assume the rate of respiration in darkness. The temperature all the while was kept steady, as the heat from the lamp was absorbed by a screen of flowing water interposed between the lamp and the plant material.

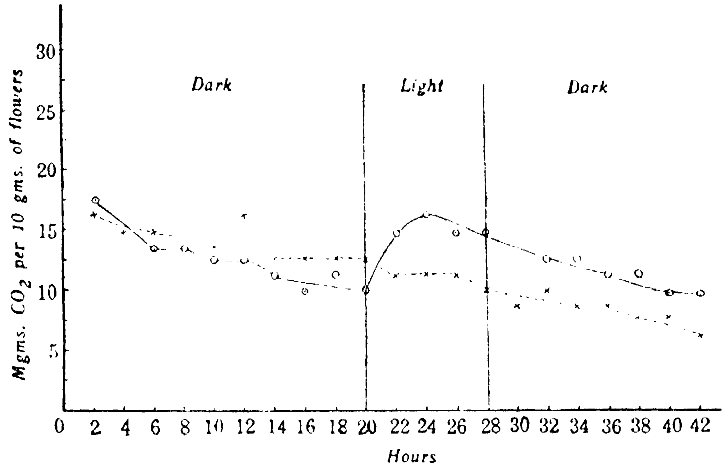
This rise in respiration can only be due to the catalyzing action of light. Further proof of this was furnished by the work on the coloured flowers.

It must be noted here, however, that most of the colourless leaves of *Croton* are not wholly devoid of colour but are faintly coloured yellow. Parija [27] and Saran's work confirm these results. Working on the albino varieties of *Aralia* they found that by exposing these plants even to a short period of diffused

light, the respiration rate after the exposure got augmented. It is quite probable that these albino varieties like the faintly yellow leaves of *Croton* contained some pigment.

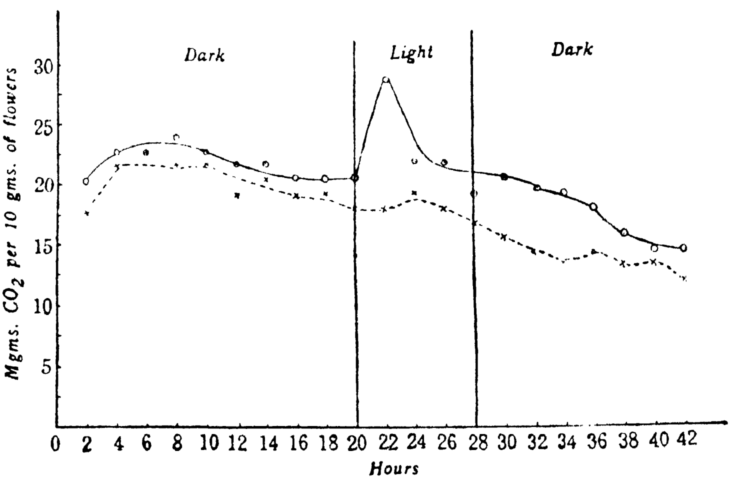
THE RATE OF RESPIRATION OF SOME COLOURED FLOWERS

Ranjan and Saxena [33] working on the inflorescences of *Bougainvillea*, (yellow and pink) *Nerium* flowers and yellow



(*Nerium*—pink)

FIG. 3.

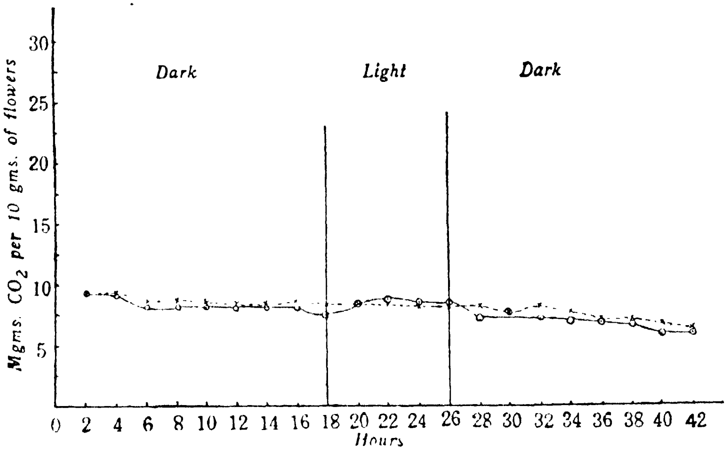


(*Bougainvillea*)

FIG. 4.

Canna flowers, found that the floating respiration in both *Bougainvillea* and *Nerium* showed the usual fall and when after about 18–20 hours' light was administered from a 1,500 W. Osram lamp kept at a distance of one foot, the respiration rate quickly went up. Once the high peak was reached, the respiration rate, however, slightly declined off even in light.

When the plants were brought back to darkness, the respiration rate steadily fell off. The respiration of *Canna* flowers, on the other hand, behaves somewhat differently to the respiration of *Nerium* or *Bougainvillea.* In *Canna*, Fig. 5, one notices a total absence of any fall in the 'floating' respiration while the increase in the respiration rate in light is only very slight. Thus there appears to be a certain co-relation, between the fall in the 'floating' respiration and a rise in the respiration when plants are exposed to light.



(*Canna*)

FIG. 5.

This fact leads us to suggest that if normally the floating respiration keeps low from the very start, then the subsequent exposure to light will bring about no change in the respiration rate.

The analysis of both the plastid and anthocyanin pigments of these flowers revealed that whereas in *Nerium* and *Bougainvillea* these pigments were in abundance, *Canna* flowers contained very little of them. If now, the solar energy of the right frequency is arrested by such pigments, then the carbohydrate molecules in *Nerium* and *Bougainvillea* will necessarily get activated and so bring about increased respiration. From the same viewpoint the respiration of *Canna*, which contained less of these pigments, will remain low in light.

In the cases of *Nerium* and *Bougainvillea*, there was a long continuous fall when the plants were brought from open sunshine to darkness in the laboratory and so also there was a long continuous fall after the laboratory illumination to darkness. (See figs. 3 and 4.) This feature is of considerable importance, for, while assuming that respiration in light is also a photochemical process, one will not be able to apply Einstein's law of photochemical equivalence. For, we have seen that even when light is cut off the reaction goes on at a relatively fast rate, though diminishing in its rate during successive hours. In-vitro experiments on photochemical reactions may give us some insight into this type of complicated reactions. For instance, in the case of chain reactions met with in certain types of photochemical actions the products of reactions liberate sufficient energy to activate additional reactants, causing a chain of reactions to take place. An illustration may serve to explain the point. In the formation of HCl from H_2 and Cl_2, the following chain reaction is supposed to take place.

$$\begin{aligned} Cl_2 + \text{light} &= 2Cl. \\ Cl + H_2 &= HCl + H. \\ H + Cl_2 &= HCl + Cl. \\ Cl + H_2 &= HCl + H. \quad \text{And so on.} \end{aligned}$$

As I have said before it is now well established that even in exothermal reactions the reacting molecules have to get excited before they can react and I cited the case of a ball which has to be pushed from a roof before it can fall and thus lose its energy. Now in the photochemical synthesis of HCl from H_2 and Cl_2, if q be the energy given out in the reaction and $h\nu$ is the energy which is necessary to activate the Cl_2 molecule, then in the reaction the energy given out will be $q - h\nu$. Obviously, this energy is greater than $h\nu$, and is, therefore, sufficient to activate a second molecule of chlorine, which on reacting will liberate again a sufficient quantity of energy to bring about a reaction of the third molecule.

If the energy is not dissipated away then once a reaction starts it will continue indefinitely. But the energy does get dissipated hence a gradual loss in the reaction rate. The slow fall in the rate of respiration when plants are brought from light to darkness, could also be explained on somewhat similar lines, viz. (1) the accelerated pace set up in light continues owing to chain reactions even in darkness, but (2) owing to other reactions in which catalysts are likely to play a part, the chain reactions break up and the respiration rate drops off.

The quick rise of the respiration rate and its subsequent slight fall even during the period of exposure to light is more difficult to explain and may be due to a variety of causes, amongst the foremost of them being the effect of light on (1) the permeability of the protoplasm, (2) the viscosity of the

protoplasm, (3) the plasma membrane, (4) the action on enzymes, or (5) the formation of internal filters.

In this short paper it is not possible to give full justice to the works of various investigators on these problems, but a few of the more important recent works will be dealt with.

Lepeschkin[22] using the pulvinus cells of *Phaseolus* and *Spirogyra* filaments concludes that light increases the permeability to KNO_3 with increased illumination. He used the isotonic coefficient method. Later Zycha[42] criticized this method and showed that Lepeschkin's results are unreliable. Hoffmann using the Hofler plasmometric method also finds an increase in permeability. Hoagland and Davis[18] measured directly the amount of anion accumulating in the sap of *Nitella* in darkness and in white light. They found that light accelerated the accumulation of the anions. These authors think that light causes a change in the metabolic process. On the whole, there is a preponderance of opinion in favour of the increase in permeability in light. If that were so, then the decrease of respiration in prolonged exposure to strong light may be ascribed to this phenomenon.

Moreover, light also affects the viscosity of the protoplasm as has been shown by Huber[20], Weber[39] and others. Weber noted the difference in the form of plasmolysis. Convex plasmolysis is associated with relativity low viscosity and concave with high viscosity. Leaves in darkness show 'convex' while leaves in light show concave plasmolysis. Hence he concludes that viscosity is higher in the light than in darkness.

Heilbrunn and Daugherty[17] have shown that ultraviolet light releases calcium from the cell cortex, which then enters the protoplasm proper causing first liquefaction and then gelation. Now, as it is supposed, if the plasma membrane of a cell is a calcium gel, then light radiations will weaken such a gel by the removal of the calcium and consequently the permeability will increase.

The action of radiations on the enzymatic system is yet imperfectly understood. Most of the work so far done has been with the extracts of enzymes, and that too in its impure form. So that it will be unsafe to draw definite conclusions from the results of experiments done in-vitro. But some in-vivo results are summarized below.

Green's[16] work upon the action of light upon diastase solution, and upon diastase of the leaf showed that bright sunlight had no effect.

Knott[21] found an increase in catalase activity of spinach after lengthening the photoperiod. Baly and Semmens[2] also report that when a strong beam of polarized light was made to fall upon the starch of potato, wheat, and corn, a rapid hydrolysis of starch to sugar occurred. On the other hand, Pincussen[28]

observed the destruction of diastase by light in the presence of oxygen.

Ranjan and Mallik[32] showed that an exposure of green leaves to light increases the hexose content and this formation of hexose is correlated with the increase of catalase activity.

It may, in this connection, be also mentioned that Chatterji[8] found that injection of alcohol in the leaves of *Eugenia jambolana* similarly increased both the hexose content and catalase activity.

Pal's[26] work shows that light may have considerable effect on the respiratory activity of fatty materials by changing the lipase activity and thereby altering the fatty acid—glycerol carbohydrate equilibrium. His work on Spirogyra[25] shows a profound effect of light on the metabolism of the algae in the conjugating stages probably due to some changes in the enzymic activities.

That the fall in the respiration rate of leaves, when exposed to prolonged period of illumination may be due to the formation of 'internal filter' is also possible. Oxygen may be one such filter. For during the exposure to light, carbon assimilation starts within the leaf and the consequent formation of oxygen takes place. It had been shown in in-vitro experiments that O_2 acts as a negative catalist. Its retarding influence on the photosynthesis of HCl has been noticed. Dhar finds that oxygen retards the reduction of mercuric chloride by potassium oxalate in the dark. And Allmand and Webb[1] have shown that the photolysis of potassium ferric oxalate practically stops on bubbling oxygen through the solution. Thus the slight fall in the respiratory rate may be due to some of these causes either acting singly or jointly, when leaves are subjected to prolonged exposure to light.

The Respiration Rate of Roots

I have said before that the respiration rate augments in light only in those cases where light energy of the right type is absorbed. This fact is further proved by experimentation on roots. For this work Pistia roots were chosen for the *Pistia* plant being a floating form, its roots are particularly suitable for experimental purposes. These roots, previous to their being put in the experimental chamber, were exposed to 2 hours of direct solar radiations.

Unlike the respiration rate of leaves the respiration here is a flat horizontal curve and shows no fall in the floating part (Fig. 6). The rate of its respiration was found to be about the same as the 'protoplasmic' respiration of its shoots per gram of the plant material. Previous exposure to light brought no change in the respiration rate. This explains two points: (1) the roots being colourless, light energy, which could cause activation of the molecules is not absorbed, and (2) the 'protoplasmic' respiration of green plants is the normal respiration in darkness.

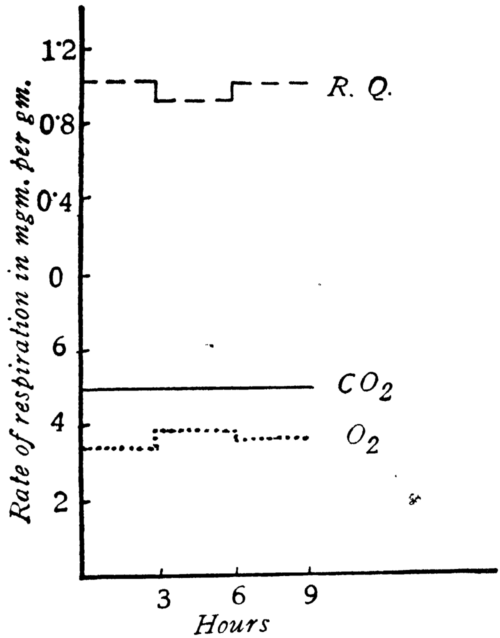


FIG. 6.

THE RESPIRATION RATE OF GREEN LEAVES IN LIGHT

From these considerations we now pass on to the respiration of green leaves in light. As is obvious, in light a green tissue will not show the emission of CO_2, for as soon as it is produced in respiration, its reduction to carbohydrates will take place and no CO_2 will escape out of the stomata. Thus it is only by indirect means that the respiration rate in light can be found.

The experiments on *Eugenia* leaves [29] show that when light from a 1,000 W. Osram lamp was given from a distance of one foot from the plant chamber, the CO_2 of respiration in the pettenkofer tubes rapidly declined off as the photosynthesis (Fig. 7) increased. After 15 hours of exposure the leaves were again darkened and the CO_2 in the pettenkofers went up.

During the period the leaves were in light, assimilation was going on and if even all the CO_2 of respiration was built back by assimilation—which of course is not the case—then at the end of light the rate of respiration should be the same as at the beginning of the illumination for the carbohydrates being the basic materials for respiration, their concentration should be the same at the end of light as at the beginning.

The 'after effect' of light, however, shows that the CO_2 emission gradually increases, hour by hour, to a value which is in excess of the respiration rate just prior to light exposure;

and soon after attaining a maximum value the respiration rate starts to fall off. Now, if we accept the hypothesis that the respiration is higher in light and that it gradually falls off in darkness, then the way to find out the respiration rate of a green leaf, in light, is to produce backwards the falling curve of respiration to the time at which light was switched off, i.e. to the time at which darkness began or to the zero hour of darkness. This has been drawn backwards in Fig. 7 marked A. The

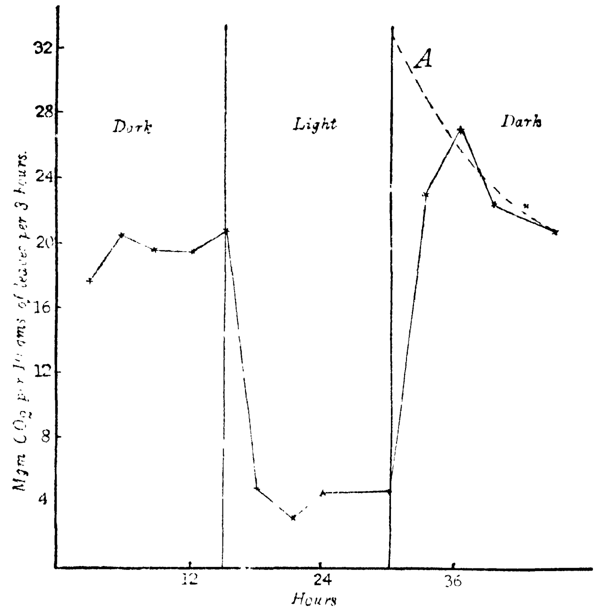


FIG. 7.

respiration rate, according to this hypothesis, is over 32 mg. CO_2 per 10 gm. of leaves per 3 hours in light but in darkness it falls off to about 20 mg. CO_2 per 3 hours. And the falling curve in-between these points (the floating respiration) is the 'after effect' caused by the primary photochemical process setting up 'chain reactions'. This thus accounts for the subsequent high rate of respiration for at least some time, even after the illumination is removed. That the 'after effect' may last for several hours, has also been shown in in-vitro experiments. In the case of mercury vapour it has been observed that the life period of the excited atom is of the order 10^{-6} sec. But recently Wood [41] has observed that if a mercury lamp is started and then switched off the glow persists for several seconds. In the case of solutions, Ghosh [15], Dhar [12] and others have shown that the 'after effect' has been found to exist for about 2 or more hours.

In the case of ferrous sulphate and iodine, Dhar and Mukerji [12] found the 'after effect' to last for 2 hours and 15 minutes, while in the case of the bleaching of dicyanin the 'after effect' continued for 4 hours and 10 minutes. It may be argued that this difference in the life period of the active molecules is due to the complex nature of the solvent molecules with which these authors have worked. I may, therefore, venture to suggest that the nature of the plant cells is more complex and naturally once they are activated the 'after effect' may last for a long period.

That the high peak of respiration is not reached all at once in experimentation is due to the numerous structural difficulties which impede the flow of CO_2 from the parenchyma cells of the leaf to the pettenkofer tubes. And by the time the new adjusted state can be arrived at, the respiration rate drops off hour by hour as the 'after effect' damps off in darkness.

Parija and Saran [27] have shown that light has no effect upon the respiration rate till after 40 hours in darkness. It is probable that for their leaves the first 40 hours are the period of floating respiration when the 'after effect' of light, due to the secondary photochemical reactions, is taking place. (Here the leaves were brought from light to the dark experimental condition of the laboratory.) And if during this period of 'after effect' light were to be administered it might not show any effect. It is only when the effect of light has died down, e.g. at the protoplasmic level, that the illumination will increase the respiration rate of leaves.

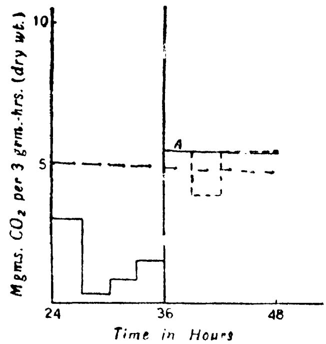
I shall now attempt to discuss a few records of experimentation on the influence of temperature on photochemical reactions in respiration.

The Temperature Effect upon Light Respiration

In-vitro experiments by various investigators have shown that generally speaking the temperature coefficient of a reaction occurring in light is much greater than unity but is smaller than that of the reaction in darkness. Dhar [11] finds in the case of the oxidation of potassium oxalate by iodine that in darkness for a 10°C. rise it has a value of 7·2 while in diffuse light the temperature coefficient is 3·4. This is due to the activation of most molecules in light and thus further activation with rise of temperature is relatively smaller.

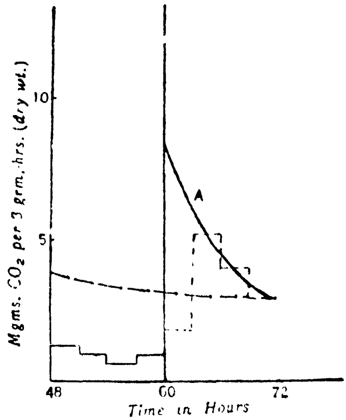
The work [30] on the temperature effect was done with the entire plants of *Pistia* which possesses a rosette of green leaves. The range of temperature varied from 20·5°C. to 40°C. Figs. 8–11 give the respiratory index of the plants in light and darkness at temperatures of 20·5°C., 27°C., 35°C. and 40°C. The arrowhead lines show the course of the protoplasmic respiration in darkness, and the continuous lines point out the low CO_2 emission as seen by titrations of the contents of pettenkofer

tubes due to the partial assimilation of the CO_2 given out in respiration in light. The dotted line shows the respiration rate in darkness after exposure to light.



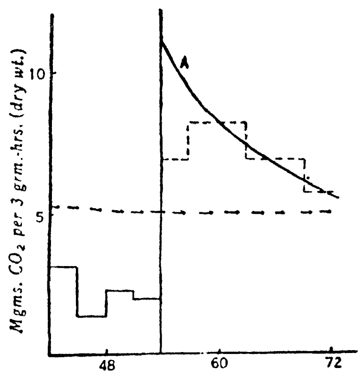
(Temp. 20·5°C.)

Fig. 8.



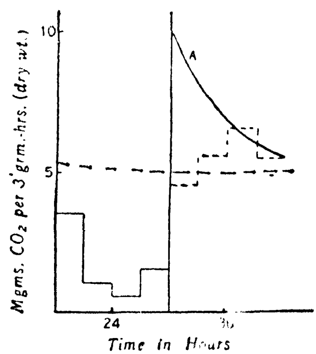
(Temp. 27°C.)

Fig. 9.



(Temp. 35°C.)

Fig. 10.



(Temp. 40°C.)

Fig. 11.

Following up our previous method, of studying the 'after effect' of light, to find out the respiration rate during the period the leaf was illuminated, one finds that the respiration rate gradually falls in darkness till its final particular temperature level is reached. The respiration curve is now drawn backwards to the zero hour. This is shown by curves marked A in Figs. 8–11.

I must confess here that these curves marked A are fairly arbitrary and can be subjected to certain amount of variations.

Nevertheless, they bring out forcibly the basic facts that differences in increased respiration in light do exist at varying temperatures. The zero hour levels show that at 40°C. the respiration rate in light was in the neighbourhood of 10 Mg. CO_2 ; and at 35°C. 11·1 Mg. CO_2; at 27°C. 8·5 Mg. CO_2 ; and at 20·5°C. only 5·5 Mg. CO_2.

It is important now to know the relative increase of the respiration rate in light over the respiration rate of leaves in darkness. The measurements of this rise in the respiration rate in light show that it is twice at 40°C. while at 35°C. it is 2·2 and at 27°C. it is as much as 2·5 times. While at 20·5°C. the increase is only about 1·1 times. We thus find that the maximum rise in the respiration rate in light is at 27°C. though the maximum intensity is at 35°C. This marked increase in both rise and intensity which we find within the limits of 27° and 35° decreases with higher temperatures. On the other hand, the relative increase is again very small at low temperatures.

Scheme of the Reactions and the Energy involved

We assume that in respiration, as in photosynthesis, there are at least two reactions: (1) the primary reaction and (2) the secondary reaction; the former is both thermal as also photochemical, while the latter is only thermal.

For convenience let us resolve these reactions in accordance with the following scheme:—

$$\underset{(1)}{A\text{—}B}\underset{(2)}{\text{—}C}$$

A—B is primary and B—C is secondary. The rate of B—C will depend upon the rate of A—B. In dark at 20°C. both A—B and B—C are slow and the rate of respiration is consequently slow. If now light is given A—B becomes accelerated while B—C remains slow. Thus the reaction here is limited by the rate of B—C which being thermal, the augmentation of respiration by light does not take place at this temperature. At 27°C. the rate of reaction B—C is capable of being faster than at 20°C. But the primary reaction A—B is not so much accelerated, for this reaction is also a photochemical one and not only a thermal process. Therefore, here the rate of reaction is not controlled by B—C but by A—B. Therefore, when light is given this primary reaction increases and as B—C is already in excess of the limiting value due to increased temperature, there is an increased respiratory rate. At 35°C. due to the primary reaction being thermal, to a certain extent, the reacting molecules are already in a greater excited state than they were at 27°C. But as there is a limit to the number of molecules which can be thus excited, the administration of light, although it does cause slightly greater excitation of molecules, cannot do

so beyond a certain limiting value. Thus even if there is a higher reaction rate, the relative increase in the respiration rate is less at 35°C. than at 27°C. The same holds good for respiration at 40°C. with this additional reason that at this temperature the time factor also becomes operative.

In Blackman's scheme [4] the reserve carbohydrates break down to sugars and these then go into the activated forms with a higher energy content. This reaction causes activation which according to the scheme given above should correspond to the 'primary process'. In the 'secondary reaction' which is purely thermal, these activated forms break down, in glycolysis, to substances with half the number of carbon atoms. That enzymes and temperature play their respective rôles in these reactions is beyond question.

The following scheme is suggested:—

Hydrolysis.

Carbohydrates $\longrightarrow n$ (Glucose).

Primary reaction.

2 glucose + $hv \longrightarrow$ glucose′ + glucose.

Secondary rection.

Glucose′ + En $\longrightarrow 2C_3H_6O_3 + q$.
2 glucose + $q \longrightarrow$ glucose′ + glucose.
Glucose′ + En $\longrightarrow 2C_3H_6O_3 + q$.
And so on.

N.B.—En = Enzyme.
q = hv + the difference of the energy between $C_6H_{12}O_6$ and $C_3H_6O_3$.

Repurcussions of Light Respiration on Carbon Assimilation

We will now finally close this discussion with a consideration of the repurcussions of these results on our knowledge of carbon assimilation by green plants. As we all know in the study of carbon assimilation we first note the apparent assimilation rate and then add to this, the CO_2 of the respiration which gives us the real assimilation value. The CO_2 of respiration is usually taken by noting the respiration rate, just before and after light and the mean of the two gives the respiration rate during the period of assimilation. If now the respiration rate definitely increases in light and also, as has just been pointed out, this increase varies with temperature, the previous work done on the

rate of real assimilation becomes of rather doubtful value. Some work has been done in this laboratory by the writer [31] on the carbon assimilation of *Eugenia jambolana* leaves at varying temperatures. These results are summarized in Fig. 12 in which

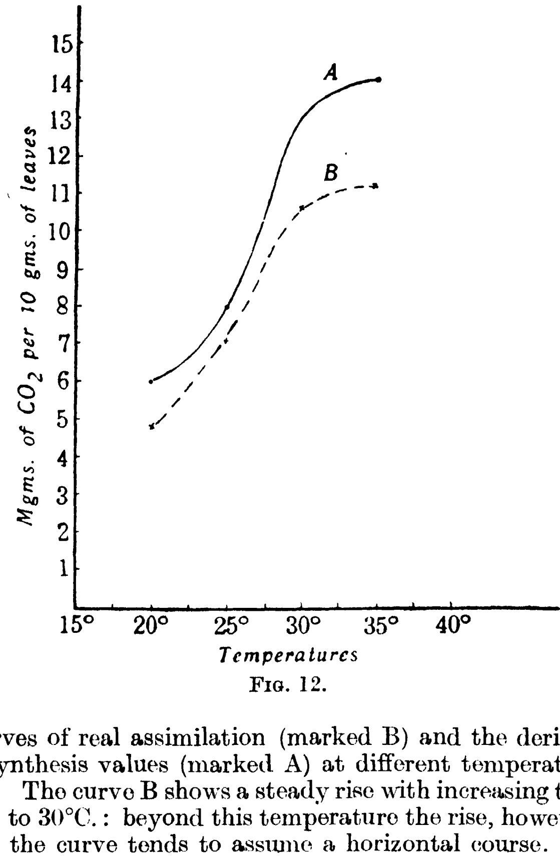


FIG. 12.

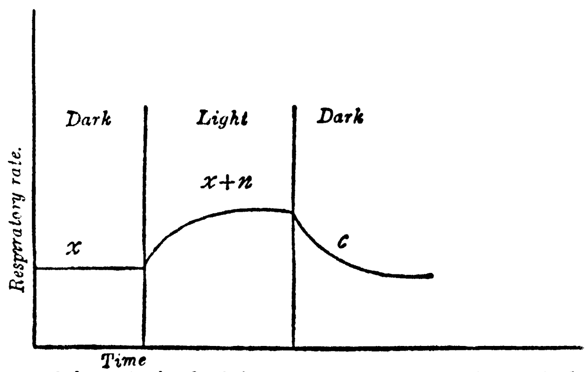
the curves of real assimilation (marked B) and the derived real photosynthesis values (marked A) at different temperatures are shown. The curve B shows a steady rise with increasing temperature up to 30°C.: beyond this temperature the rise, however, falls off and the curve tends to assume a horizontal course. On the other hand, the curve A follows an S-shaped course indicating a slow rise between 20°–25° and 30°–35°C.: between these two extremes the curve indicates a rapid acceleration. These results are consonant with the view that near about 20°C. the secondary thermal reaction is limiting the respiratory rate and as the dark reaction in photosynthesis, being thermal, also remains limiting then the Q_{10} values for assimilation between 20°–25°C. will be low. Between 25° and 30°C., however, the increase in the respiratory rate is at its maximum in light. This would seem to indicate that between these temperatures the relative increase in assimilation or the Q_{10} for assimilation would be the highest also. This is actually found to be the case, for the assimilation curve

shows a steep rise between 25°–30°C. Beyond these temperatures the Q_{10} for respiratory rate decreases and so also the Q_{10} for assimilation.

CONCLUSION

Ladies and gentlemen, we may, therefore, conclude that the green leaves and the beautiful flowers that one sees, not only colour for us all the world of vegetation and with their beauty fill our hearts with joy; but they also do something more. To quote Sir William Bragg they help the world to make the first step in the life process. The green pigment chlorophyll of the leaf, as we all know, is vital for building up of our food. But the orange yellow pigments, carotin and Xanthophyll which are found along with the chlorophyll of leaves and which give colour to many flowers, have also a certain definite rôle. Not only are they responsible for the formation of certain vitamins but they also serve the oxidative processes in the leaves and flowers by absorbing the blue-violet rays of the sun and transmitting the energy so absorbed to the reacting metabolites in these tissues.

The beautiful reds, purples, blues and yellows of many flowers and the reds of tender young leaves are due to the anthocyanin pigments. These too like the hydrocarbon pigments absorb the radiant energy and transmit it to the relatively slow oxidizing metabolites to rapidly increase their oxidizing power, so vital to the actively dividing cells of a young leaf or to the developing young embryo of a flower. The respiration rates in these cases will then follow a course shown graphically in Fig. 13.



Schematic sketch of the respiratory graph in light and dark.

FIG. 13.

Suppose the rate of the protoplasmic phase of respiration is x; now when light is given the respiratory rate of a green or coloured tissue increases gradually to $x+n$; then again when

darkness is restored there is a gradual fall till the curve assumes a constant level the value of which is again x. This part of the curve (as shown by c) is the exact replica of the graph obtained when the plant material is brought from light to the experimental conditions in dark; the gradually falling part, which we might say the 'after effect' of light, is comparable to the floating part of respiration in darkness and the level part to the protoplasmic phase.

The interaction of light and darkness on the activation of molecules and enzymes is best explained by the following scheme (Fig. 14).

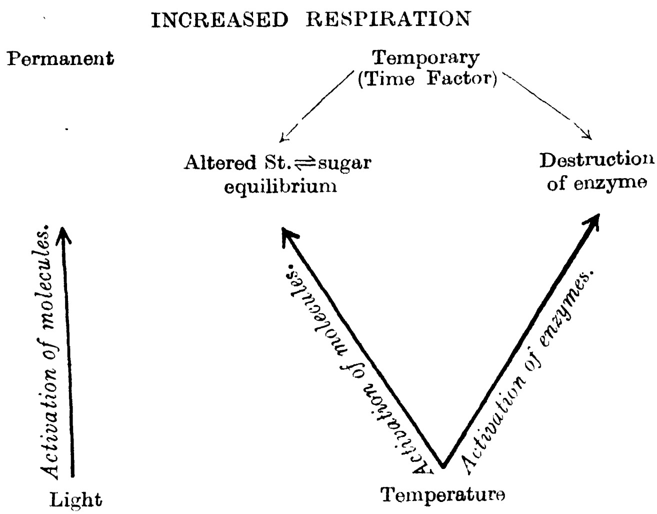


FIG. 14.

The increase of respiration by light is due in fact, to a large extent, to the activation of more of the reacting molecules in light than in dark at a given temperature. Although a very high temperature activates the molecules to a higher quantum state, it also destroys and renders inactive the enzymatic complex which attacks the activated molecules.

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SECTION OF ZOOLOGY

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Presidential Address

(*Delivered on Jan. 5, 1941*)

SOME ASPECTS OF MAMMALIAN PLACENTA

I thank you very much for the honour you have conferred on me by electing me this year as the President of the Zoology Section of the Indian Science Congress. I am aware of my limitations as a zoologist, for till very recently it was my privilege to teach Physiology to the students of the Medical College in Mysore. I confess I felt greatly embarrassed in choosing a topic to speak to you about. Since the last meeting of the Science Congress in Benares, Zoological Research in our country has assumed relatively vast proportions as is evidenced by the steady increase in the number of papers presented year after year before this section.

A perusal of the learned addresses of my predecessors has impressed upon me the variety of subjects open for serious thought, but at the same time, no hard and fast rule appears to have been laid down as to the choice of the subject. It has however been usual for the President to present in his address an account of some piece of his own research, or to summarize the progress of research in his subject. My first thought was to devote this opportunity to outline the significance of the study of that fascinating group of animals, viz., Lemuroidea, but on consideration I decided to review on this occasion some aspects of the Mammalian Placentation. There have appeared several illuminating monographs in which the phylogeny and morphology of the Placenta have been admirably discussed and to those interested in these aspects of the subject the lectures of Sir William Turner [1] and Robinson [2] and the monographs of Duval [3], Strahl, Jenkinson [4], Assheton [5], Grosser [6], Marshall [7], Hill [8] and Wislocki [9] would yield much information. The subject that has intrigued me is its nutritional function. It is essential to know, and indeed it is considered a good principle, to understand the precise meaning of the terms. I shall therefore attempt a brief answer, without going too deeply into its history, to the question 'What is Placenta?' Seventeenth century may be correctly described as a period

in which scientific enquiry became organized. Harvey[10] was the first to state that the placenta was an organ which elaborated from the maternal blood, the food required for the development and growth of the foetus. Mayow[11] considered that the placenta performed the functions of a *foetal lung*. John and William Hunter put forward the view that the maternal blood circulated through the placenta—a view that materially assists in appreciating the functions of the placenta. From the time of Harvey to that of Jenkinson our conception of placenta has undergone some little change and Jenkinson in his monograph on Vertebrate Embryology states that the placenta is that organ in which the blood vessels of the embryo are brought into intimate anatomical and physiological relation with the spaces—which may be blood vessels or lacunae of quite a different character—in which maternal blood is circulating. The teaching of Otto Grosser, with whom most students of Mammalian Embryology agree, is that placentation may be defined as the intimate junction of the mucosa of the uterus with the chorion for purposes of exchange of material between the mother and the offspring. Professor Hill has impressed on his students that the actual placenta is a composite structure being partly foetal and partly maternal. The two parts may be in simple apposition or intimately blended but in no case is there an admixture of foetal and maternal blood streams. The main functions of this structural relationship are undoubtedly those involving the supply of nutritive material and elimination of waste products. More recently Mossman has stated that 'the normal mammalian placenta is an apposition or fusion of the foetal membranes to the uterine mucosa for physiological exchange'. Mossman's definition of the term is at once brief and apt.

I shall now proceed to consider very briefly the morphology of the placenta. There are, as is well known, two types of placenta—the yolk-sac placentae and the allantoic placentae. The former, except in the native bear and the wombat, is usually of transitory functional significance. In the Eutherian mammals it is the allantoic placenta that is significant. Before the advent of high power microscopes and the microtome, the only method of classification was the one that could be done by naked eye examination. Accordingly, the placenta was said to be diffuse, multiplex, zonary, cotyledonary or discoidal according to its external appearance. This primitive classification, it is apparent, does not assist us clearly to understand either the structure or the significance of the different types. A slightly improved method of classifying the organ, based on the presumption that in certain forms there was loss of maternal tissue during parturition, was, as noted in the following table advanced by Weber, Huxley, and Strahl.

Weber.	Huxley.	Strahl.
(*a*) Caducous. (Maternal and foetal parts shed at birth.)	(*a*) Deciduate.	(*a*) Placenta Vera.
(*b*) Non-caducous.	(*b*) Non-deciduate.	(*b*) Semi placenta.

(It must be remembered that in some instances as in Huxley's contra-deciduate type, part of the placenta is retained in the uterus and finally autolyzed.)

Robinson's classification of the placenta into *Conjoined* and *Apposed* types, advocated in his Hunterian Lecture, made no great advance over the previous ones. Assheton[12] made use of the activity of trophoblast and classified the placenta into two types, viz., *Placenta Cumulate* and *Placenta plicate.* Even this division, much as it tended to explain some features in placental organization, must be held to be incomplete. The credit of establishing a system of classification, which has general approval and which constitutes a distinct advance over the binary systems, must be assigned to Otto Grosser[13]. Otto Grosser bases his classification on the exact relations of the maternal and foetal tissues. He recognized four types, characteristic features of which may now be summarized.

A. *Placenta epithelio-chorialis* type as exemplified by the placenta of the pig in which all maternal tissues are preserved, the foetal trophoblast being apposed to the uterine epithelium.

B. *Placenta syndesmo-chorialis.* In this type the uterine epithelium disappears to a large extent; and the trophoblastic epithelium is brought into contact with the maternal connective tissue as in the sheep.

C. *Placenta endothelio-chorialis* constitutes the third type in which, with the disappearance of the uterine epithelium and connective tissue, the foetal trophoblast comes into contact with the maternal capillaries as the carnivores.

D. *Placenta haemo-chorialis* type in which uterine epithelium, connective tissue and maternal capillary endothelium disappear with the result the maternal blood circulates in the lacunae formed by the trophoblast and bathes the trophoblast as in Rodentia, Insectivora, Cheiroptera, Anthropoid Apes and Man.

(Further subdivision of these main types exist, but it is unnecessary to go into details for purposes of this discussion.)

The histological study of the placenta of various groups has placed at our disposal a mass of facts which has enabled us to understand to some extent the functional significance of the relationship of the foetal and maternal tissues. The main object of the development of the Placenta is to ensure satisfactory performance of those physiological functions—supply of food, oxygen and elimination of carbon dioxide and other waste products, necessary for the growth of the embryo. In considering this aspect of the question, it is necessary to bear in mind, the now universally accepted fact that the foetal blood is always separated from the maternal blood stream. The nature of this separation differs widely in the different types of placenta. Thus in the epithelio-chorialis type the substances from the maternal blood have to pass through six different structures before they could get into the foetal blood. First the endothelium of the maternal capillary, the connective tissue around it, the uterine epithelium, the trophoblastic epithelium, the connective tissue of the allanto-chorion and the endothelium of the foetal capillary. In the Syndesmo-chorialis type, for the most part, the uterine epithelium is lacking and the materials have to pass through the existing five layers of cells. In the endothelial type, the trophoblast, as stated already, comes into intimate contact with the uterine capillaries and the barrier for the passage of substances is reduced to four layers, till at last in the haemo-chorial type with the disappearance of the walls of the maternal capillaries, the maternal blood bathes the trophoblast and the barrier is reduced to three layers of cells. In effect the thickness of the placental membrane varies in different animals.

It is obvious from the foregoing, that the exchange of material between the mother and foetus is conditioned by a variety of factors peculiar to each type of placenta. In its passage through the Fallopian tube, the fertilized ovum depends on the secretion of the surrounding tissues for its nourishment; and when it reaches the uterus, till it attaches itself to the uterine wall, and for some little time even after that, the growing embryo derives its nutrition from the secretion of the uterus. But with the establishment of the placenta, the nutrition of the embryo is effected by the direct absorption of the products of uterine mucous membrane directly by the trophoblast; and with the vascularization of the allanto-chorion, the foetal nutrition is by the transference of material from the maternal to the foetal blood. The normal requirements of the foetus comprise the proteins, carbohydrates, fat, water, salts and vitamins. It is a well-known fact that the digestive products entering the

blood stream of the mother are circulating in the blood. The fats particularly are on a different footing, since during absorption they are resynthesized and reach the blood through the medium of lymphatic vessels in an extremely fine state of division. Hence the mode of passage of proteins, carbohydrates and fats across the placental barrier differs. The proteins are transferred as amino-acids to the foetal blood; and indeed a large number of investigators have succeeded in noting the presence of amino-acids in the foetal blood. It may, however, be stated that our knowledge concerning the exact nature of amino-acids passing from the maternal to the foetal blood is, as yet, in an unsatisfactory state and research on maternal and foetal bloods of animals with different types of placenta would, I have no doubt, yield valuable information.

Concerning the supply of carbohydrates, it should be observed that the glycogen store of the mother is the chief source although the possibility of the conversion of other food material after absorption by the foetus must be borne in mind. The rate of absorption and utilization of carbohydrates by the mammalian embryo is known to some extent, but extended investigations on Primates other than Man would perhaps yield information of much value. I make this suggestion in view of the abundance of monkeys in India and the relative ease with which they may be obtained.

Information as regards the transport of fat from the maternal to foetal blood stream is far from satisfactory. In recent times our ideas as regards the mode of transport of fat have changed to some extent. The explanation that the leucocytes of the maternal placental part, loaded with fat, migrate into the foetal part to supply the necessary fat has been reinforced. It is now held, as a result of the investigations of Sinclair,[14] McConnel and Sinclair [15] on the placenta of the rat, of Bickenbach and Rupp [16] on that of the rabbit, and that of Boyd and Wilson [17] on the human placenta, that the fats may either pass directly across the placental barrier to the foetal blood, thence to the foetus by way of the umbilical veins, or that the maternal placenta may act as a secreting organ, taking up the fat from the maternal blood stream, and passing it on to the foetal blood with or without modification. Although one or the other of the views just now mentioned may represent actual state of affairs, it should be borne in mind that the enzymatic activity of the trophoblastic cells may also play an important part in the transfer of this material. Further, it has been observed that the fat content of the placenta decreases with age and an answer to the question whether the placenta acts as judicious regulator of fat supply to the growing embryo would assist in evaluating the function of the placenta. Here again is a problem which promises fruitful results.

Our knowledge of the nature of placental enzymes is meagre, and a well-planned study of the subject appears to me to be urgent and important. In view of the conflicting opinions that have been expressed as regards enzymes in the placenta, it is advisable to select for study, as Needham suggests, a placenta type which is readily separable into maternal and foetal parts, and to follow carefully the activity of any single enzyme throughout pregnancy.

The supply of vitamins to the growing embryo constitutes a very important factor in its normal development and attention may be drawn to lack of reliable information about the rôle of vitamins other than that of 'E'.

Except for the noteworthy contributions of Fenger on the placenta of the cow, not much is known about the mineral metabolism in the mammalian placenta.

I now proceed to consider the placenta as an organ of foetal respiration. The supply of oxygen to the fertilized ovum and elimination of carbon-dioxide may be said to be effected, till implantation, by the blood circulating in the Fallopian tube and uterus. It is only after vascularization of the allanto-chorion that the placenta begins to function as an organ of foetal respiration. It has been observed that the passages of two gases in opposite directions is determined by a variety of circumstances depending upon the nature of the placental structure. In any case, in normal development, respiration like nutrition is undoubtedly efficient in the species concerned. The problem whether the nature of blood, more particularly the nature of its haemoglobin, has any influence on respiratory activity needs consideration. It is universally known that haemoglobin has the power of carrying oxygen, as also carbon-dioxide in an easily dissociable state. Although in the normal gravid animal foetal respiration is efficiently carried out, both the quantity of oxygen needed and the rate of exchange of gases differ in different groups of animals. The recent researches of Barcroft and his collaborators have demonstrated that the foetal haemoglobin differs from that of the mother in the few animals that have been studied. Before any answer can be suggested to the question whether the structure of the placenta is in any way affected by the nature of the foetal haemoglobin, much more exhaustive enquiry with reference to a wide range of mammals is needed. It is, however, interesting to observe, in this connection, that the studies of Boor and Hektoen indicate that the carbon monoxide haemoglobin from different mammals is species specific. Further, it has been observed that there are noticeable differences in the property of the blood of different animals and such differences may be due to specific differences—both qualitative and quantitative in their haemoglobins. Thus it may be assumed that respiratory functions of the placenta are varied in different species of mammals. It may perhaps not

be illogical to assume that the metabolic needs of the developing embryo in different species of mammals vary and the oxygen requirements accordingly differ. Hence it is reasonable to state that the placental barrier, in each species, for the passage of oxygen and carbon-dioxide develops so as to meet the demands of the growing embryo. It has been noted above that in Grosser's classification of the placenta, the thickness of the placental membrane and the cellular constituents thereof differ. The membrane permits the passage of both the nutritive materials and respiratory gases. This phenomenon can only be attributed to the few special qualities of the living membrane, conditioned by the chemico-physical characteristics of both the maternal and foetal blood streams. The problem that waits satisfactory solution appears to me to be the physico-chemical properties of the placental barrier in different groups of animals with reference to the rate and intensity of exchange of materials.

Many zoologists (Hill, Grosser, etc.) whose inclination has been to study the structure of the placenta have maintained that the epithelio-chorialis type is primitive and that the haemo-chorialis type is very highly specialized. There are others (Wislocki, Mossman and others) who have strongly supported the view that the haemo-chorial type is the primitive organ and that all other types are secondarily derived. Convincing arguments may be adduced in favour of either view, but an unbiassed analysis of available data tends to support the former view. It is, however, not my object to discuss the phylogeny of the placenta but consider it only as an organ of foetal nutrition. It may not be unreasonable to assume that the urgency of the metabolic needs of the growing embryo determines the structure of the organ of foetal nutrition. The adequacy of foetal nutrition may be said to determine the normal development of the foetus. The metabolism of the pregnant mother who has to supply the energy needs of the additional living protoplasmic tissue as represented by the growing embryo, becomes affected. It is no doubt true that a vast amount of information regarding nutritional requirements of the pregnant mother is available; yet it can by no means be stated to be complete. This subject opens up a fruitful field for future research. I hope I shall not be considered a trespasser if I were to entertain the hope that in the newly established ante-natal clinics in Indian Maternity Hospitals, the subject of nutrition of the pregnant mother will form the subject of serious research.

The studies of Physiologists, Biochemists and specialist medical men have tended to prove that efficient nutrition exercises an enormous influence on the general welfare of the animal and indirectly on the quality of the germ cells which are formed afresh throughout the greater part of life. Thus it may be inferred that the characteristics of the progeny would perhaps in the long run be improved. It has now become the

concern of Progressive Governments to enquire into the nutritional needs of live-stock and man. With this end in view Nutritional Research Laboratories have been established. Work of national importance has been turned out in these laboratories and it may be hoped that attention would also be directed to a study of foetal nutrition.

Even a rapid glance through the Records of the Indian Museum, *Journal of the Bombay Natural History*, *Journal of the Royal Asiatic Society of Bengal*, and the publications of learned bodies such as the National Institute of Sciences, National Academy of Sciences and the Indian Academy of Science, and the journals published by some of the Indian Universities convinces one that a vast amount of original work in Zoology has been done in India but equally impressive is the fact that the work is mostly morphological in its widest sense. Morphological studies, however essential and useful, it seems to me, must be made more dynamic. Zoologists have already rendered great service by their study of the microscopic anatomy of the placenta and by their interpretation about the functions of the structural units. Thanks largely to the recent researches of physiologists and biochemists, much useful information regarding foetal nutrition is available. There are, as the literature on the subject reveals, many aspects of the problem, and some of which I have already referred to, about which our knowledge is incomplete and our ignorance immense. Here in India as in the other more advanced western countries, adoption by zoologists of experimental methods in their investigation, I feel confident, would result in more valuable contributions.

In conclusion, I venture to plead for a co-operative effort by the zoologists, physiologists, specialist medical men and biochemists in a well-planned study of foetal nutrition.

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SECTION OF ENTOMOLOGY

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Presidential Address

(*Delivered on Jan. 6, 1941*)

SOME OBSERVATIONS ON THE PERIODICITY OF LOCUST INVASIONS IN INDIA

CONTENTS

INTRODUCTORY

My foremost duty is to express to all of you my deep appreciation of the great honour you have done me in electing me to preside over the sessions of the Entomology Section. I regret, however, to say that I feel conscious that I have not been able, on account of various unfortunate circumstances, to do full justice to my duties in this respect.

Having been engaged during the last ten years of my life in work connected with locust investigations, it should not be altogether surprising to you to find that I have succumbed to the temptation of speaking to you today on the subject of locusts in India, the more so because locust swarms have reappeared this autumn after an absence of over eight years, and I trust that you would kindly bear with me if you find it rather uninteresting.

Locusts have been of perennial interest to man from time immemorial, especially in tropical and sub-tropical climates. To the primitive man, the sudden appearance of hordes of these creatures in huge clouds hiding the face of the earth from the sun and filling the air with a mysterious rustle, should have often

proved a source of fright. One might imagine him looking helplessly on their descent on the vegetation roundabout and their destruction perhaps of his small patch of grain, though he might be expected to indemnify himself by collecting handfuls of them for his own consumption.

In Biblical times (*circa* 1500 B.C.), they are reputed to have functioned as one of the plagues of Egypt, and since there are references in Sanskrit literature of the early centuries of the Christian era to locusts as one of the great menaces of the cultivator, there is little to doubt that locust invasions had formed as much a feature of life in the olden days as they do at the present time.

In Europe, information regarding the occurrence of past locust infestations collected from various records and chronicles dates back to the 15th century, but in India, where historical records are generally lacking, there are no reliable data regarding locusts except for casual references to their depredations in conjunction with famines, till the beginning of the nineteenth century. Cotes (1891) in his admirable report of the locust invasion of 1889-1890 in northern India has collected together most of the available information from the beginning of the 19th century, and from data drawn from these and other sources, outbreaks of the desert locust would appear to have occurred in India in the years 1803, 1810–12, 1821, 1834, 1845 and 1860–66. It was, however, from the year 1869 that fairly detailed information regarding infestations is available, and locust swarms are known to have prevailed in the following periods:—1869–1872, 1876–1881, 1889–1898, 1901–1907, 1912–1919 and 1926–1931.

The depredation caused by locusts during the last cycle of infestation is possibly still green in the memory of the agriculturists of North India, and it was at its worst during the years 1929 and 1930, when the swarms spread almost all over the country. The situation created by the extensive damage done by hopper bands and flier swarms in the summer-autumn months of 1929 was so acute that resolutions were passed at meetings held in December 1929 of the Advisory Board of the Imperial Council of Agricultural Research and the Board of Agriculture in India recommending to the Government of India that instant steps might be taken, *inter alia*, towards the formation of a central locust bureau for collecting and disseminating intelligence on locust movements and the institution of a comprehensive scheme of locust research for the investigation of the best methods of control, for working out the bionomics of the locust and for surveying the desert areas in search of the permanent breeding grounds of the locust within Indian limits. Ultimately, funds were sanctioned by the General Body of the Imperial Council of Agricultural Research for these purposes, and an elaborate scheme of locust research was set on foot in December 1930 which continued to operate till 31st March 1939.

AN EVENTFUL DECADE OF LOCUST RESEARCH

The last cycle of locust infestation affected not only India and the neighbouring countries of Baluchistan, Iran, Afghanistan and east Arabia, but also all parts of northern and central Africa and south-western Asia and led to various schemes of investigation being undertaken by their respective Administrations, particularly by the British and French Governments. The African area was attacked not only by the Desert Locust, but by two other locusts also, viz. the Tropical Migratory Locust (*Locusta migratoria migratorioides* R. & F.) and the Red Locust (*Nomadacris septemfasciata* Serv.), besides which South Africa was also affected by the Brown Locust (*Locustana pardalina* Wlk.), which is fortunately peculiar to it.

The locust investigations carried out in the African areas have led to fairly remarkable results. In the case of the Tropical Migratory Locust, which spread over the greater part of the African Continent, covering altogether a huge expanse of over 10 million square miles, within a period of ten years, it was determined that the outbreak had originated in 1926-27 from a comparatively small area in the region of the Niger Bend in French Sudan, and, doubtless, the whole infestation might have been nipped in the bud, if the original outbreak centre had been controlled in time. Even in the case of the Red Locust, which has been active in Central and South Africa during the last ten years, the outbreak centres have been found to be confined to certain restricted areas, which it should be possible to keep under surveillance in order to prevent future outbreaks.

So far as the Desert Locust is concerned, the outbreak centres have been found to be situated partly along the coastal areas of Africa, Arabia and Baluchistan and partly in the interior, as in Rajputana and Sudan. Further investigations are apparently necessary to definitely delimit the extent of the outbreak areas, especially in western Africa and Arabia, before they can be properly supervised.

As flying swarms are often capable of covering long distances and as evidently they do not respect international boundaries, it was found essential to arrange for a system of rapid exchange of reliable information in regard to the movements of swarms, between adjacent countries. It was also felt that an exchange of notes between affected countries on their experience in regard to various aspects of locust research and locust control, would be of mutual advantage. With this end in view, the first International Locust Conference was held at Rome under the auspices of the Italian Government in October 1931, in which various countries including Italy, Great Britain, France and Egypt participated. The second International Locust Conference was held at Paris in July 1932, the third, in which I had the honour to participate as a delegate from India, at London in September

1934, the fourth, in which Khan Bahadur M. Afzal Husain represented India, in April 1936, and the fifth at Brussels in August 1938. In the last two conferences over twenty governments were represented including the United States, Canada, Argentina and other countries of the New World.

In the course of the deliberations of these conferences, various aspects of locust research were thoroughly discussed. Results presented by workers in different countries were examined and a concerted scheme of locust research was formulated, which was incorporated in a series of resolutions. The latter were circulated to the governments concerned for favour of acceptance and for taking such action as might be considered possible. Besides providing opportunities for formal discussions, these conferences made it possible for workers to get into informal touch with one another and exchange mutual experiences.

Among some of the important results of the last conference at Brussels were resolutions recommending the setting up of international organizations for the preventive control of locust outbreak centres in Africa and western Asia in respect of the important locusts of the Old World. So far as India is concerned, the creation of the Locust Warning Organization by the Government of India might be expected to serve the purpose of watching developments in the outbreak areas, but it is doubtful if it would serve any useful purpose unless it is also equipped for dealing with outbreaks as they arise. Moreover, it is not known if the authorities in Iran have consented to co-operate with the Indian organization in dealing with outbreak centres in the Iran area. Since swarms have recently reappeared in India and we are probably on the threshold of a new locust cycle, the matter is in need of further attention.

On the whole, a great deal of new ground has been broken during the last decade. The studies carried out on various species of locusts in the countries affected have greatly enriched our knowledge of the habits and bionomics of locusts in general, as well as of the ways in which they react to their environment. A large volume of evidence has accumulated on the subject of phase transformation in nature, and much clarification has been obtained in regard to the manner in which initial outbreaks are brought into being, as a result of intensive ecological studies of the natural haunts of locusts. Detailed studies of the movements of swarms since 1926 by the International Locust Centre at London have shown clearly how infestations have been developing from year to year in the affected areas, and have also elucidated the general laws by which swarm movements are governed. A great deal of progress has also been achieved in the correlation of swarm movements with meteorological data. Much light has been thrown on the life-habits and activities of the solitary phase of various locusts, and the recognition of the ability of the solitaries to make long distance migrations, similar to those

of swarms, may be said to mark a milestone in the progress of locust research.

Some of the Important Locusts of the World

In the broadest sense of the word, a 'locust' is a grasshopper that is capable of appearing in large swarms and causing damage to crops. While there is little difference in general appearance and structure, the *grasshopper* lives a solitary life scattered in small numbers all over the area, whereas the *locust* tends to congregate together both in the younger stages as hopper bands and in the adult condition as flying swarms.

There are several species of locusts in the world, which are not only restricted in their distribution being confined to particular countries and to particular types of habitats, but also vastly differ from one another in their habits.

In the Old World, the most widely distributed species is the Migratory Locust (*Locusta migratoria* L.) which is itself sub-divided into distinct races:—(1) the European Locust—*Locusta migratoria* var. *rossica*, Uv. et Zol., adapted to a cold environment and found mostly in Europe and Siberia, (2) the Tropical Migratory Locust—*L. m. migratorioides* R. & F., found in most parts of tropical Africa, (3) the Malagasy Locust—*L. m. capito*, confined to the island of Madagascar, (4) the Chinese or Philippine Locust—*L.m. manilensis*, found in the Philippines and eastern Asia, and probably (5) the Indian Migratory Locust—usually found only in the solitary phase, which may possibly prove to be a different race.

Perhaps the best known is the locust of the Bible, the Desert Locust—*Schistocerca gregaria* Forsk., found in the desert or semi-desert regions of north Africa, south-west Asia and India. Other important locusts are: (1) the Red Locust of Central Africa—*Nomadacris septemfasciata* Serv., (2) the Brown Locust of South Africa—*Locustana pardalina* Wlk., (3) the Bombay Locust—*Patanga succincta* L., found in the Indian Peninsula and Malaya, (4) the Moroccan Locust—*Dociostaurus maroccanus* Thnbg., found in the hilly areas of north Africa, southern Europe and western and central Asia, and (5) the Italian Locust—*Calliptamus italicus* L., common in Europe and western Asia.

Besides these there are various species of grasshoppers in southern Russia and Siberia, which at times multiply and assume serious proportions.

In Australia, *Locusta migratoria* occurs sometimes in pest condition, but the really serious species are two indigenous grasshoppers—*Chortoicetes terminifera* Wlk., and *Austroicetes cruciata* Sauss., which swarm regularly once in two or three years in particular parts of that continent.

In the New World, the most prominent species is the South American Locust—*Schistocerca paranensis* Burm., whose distribution ranges from the Argentine in the south to Mexico in the north. It is found in varying numbers from year to year and is most destructive in Argentina. In North America, various species of *Melanoplus* have been found to appear in destructive numbers in the United States and Canada.

These locusts differ from one another not only in their general habits but also in the manner of their adjustment to their environment, some of them being evidently more advanced in their evolution as locusts than others.

Some species have only one generation in the year, as for example, the Bombay Locust, the Red Locust of Africa and the South American Locust, but they pass the greater part of the year in the adult stage, whereas other locusts—which also have a single annual generation—lead only a comparatively short life as adults, but lay eggs which lie quiescent in the soil throughout the autumn and winter, e.g. the Russian Migratory Locust, the Moroccan and the Italian Locusts, and the Australian *Austroicetes cruciata*.

The Desert Locust, on the other hand, is one that has normally two or more broods in the year, as also *Chortoicetes terminifera* of Australia and *Locusta migratoria migratorioides* of Africa.

The Bombay Locust is a species in which gregarious habits are manifested only in the adult stage, the hoppers being found distributed as scattered individuals among grass or crops. They have never been observed to form into bands. On the other hand, in other locusts, gregarious habits are generally observable both in the hopper and adult stages.

It is those species which possess the ability to pass through two or more generations in rapid succession during the same year that are most dangerous from the point of view of swarming. Given favourable conditions, such locusts are able to multiply very quickly in numbers, and when facilities for forming concentrations are also present, they attain the stage of incipient swarming extremely rapidly. The Desert Locust, the Tropical Migratory Locust, the Brown Locust and *Chortoicetes terminifera* belong to this category and all of them are capable of reaching the stage of mass-multiplication very quickly.

On the contrary, locusts having only a single generation in the year can increase numerically and maintain their numbers, only in the event of a succession of two or more good breeding seasons, and if a good watch is kept on their progressive development year by year, it should be possible to prognosticate the possibility of mass-multiplication early enough to enable the necessary precautionary measures being taken in time for their control.

PERIODICITY OF LOCUST OUTBREAKS

The destruction caused by locusts while an attack is in progress is, speaking generally, too well known to need any special description. Since, however, India has been, till quite recently, free from attack for nearly a decade, it is possibly difficult to appreciate its seriousness.

In years of good rainfall, large areas of land are sown and by autumn the heart of the cultivator is glad at the sight of fine crops promising a bountiful harvest. All at once, however, dark clouds appear and millions of locusts settle on his fields, and in the space of a night, the look of the area is changed. Where there had been smiling crops and green pastures only bare stalks and a huge litter of dung are seen, and the locusts are gone in search of fresh fields for destruction. At other times, the swarms do not care to feed; but what is infinitely worse, they lay millions of eggs in the field before they disappear, which would mean that in about a fortnight myriads of hoppers would emerge and marching from field to field carry wholesale destruction to the countryside.

When a locust outbreak begins, it may continue for a series of 3 to 5 years on the average, at the end of which the numbers of locusts would gradually diminish until the outbreak ultimately dies out. In certain species of locusts, however, the swarms never completely disappear, though there may be a perceptible diminution in numbers over an interval varying from 2 to 4 years, after which a gradual or sometimes a sudden rise may occur. Such a fluctuation in numbers may be due to various causes, but is most commonly due to variations in weather conditions in successive years.

In the case of a great many locusts, especially in regard to the African ones, little information is on record in regard to their occurrence in the past beyond the last 50 years. In Europe, on the other hand, data are available to indicate that the European Migratory Locust had been invading Central and Western Europe from the south or the south-east since the 15th century at fairly regular intervals. In Russia, where the fluctuations in the numbers of the locust have been closely studied, the general conclusion would appear to be that the main factor in the periodic increase in numbers is the occurrence of a succession of dry years.

Uichanco (1936) has collected a mass of data for the Eastern Migratory Locust in the Philippines dating from the 16th century, from which it is clear that the species has been occurring in destructive numbers at fairly regular intervals all over the Philippine region. But it is also seen that in the endemic areas situated in the southern parts, the swarms never disappear completely, and that the periods of mass-multiplication are

generally to be correlated with a succession of comparatively dry years.

In South America, the swarms of the Locust (*Schistocerca paranensis*) never completely cease to exist in the Argentine, but are subject to much fluctuation in numbers, a series of years of high multiplication being generally found to alternate with periods of comparatively small numbers of swarms.

In India, three species of locusts are present:—(1) the Migratory Locust, (2) the Bombay Locust, and (3) the Desert Locust. Of these, the Migratory Locust is generally found in its solitary phase all over India. There are indications, however, that it can occasionally assume gregarious habits and become a destructive pest. Cotes (1891—Indian Museum Notes) mentions about 'the Madras Locust Invasion of 1878' in a note on locusts, but is not definite about the species concerned. From an examination of the printed records in the files of the Development Department of the Madras Government, kindly lent to me for perusal, I have found clear proof that the locust concerned was the Migratory Locust. It would appear to have multiplied during the heavy rains of 1877 that followed the great South Indian drought of 1876, and to have spread from January 1878 onwards from the Tinnevelly District in the south gradually north and north-east as far as the Nellore District by the end of the year, after which it gradually died out. In 1937, again, a fairly heavy multiplication of this insect occurred in the Baluchistan, Rajputana, and Kathiawar areas of north-west India, but subsided by the end of the year. It is, therefore, necessary to keep this locust under observation in view of its potentialities for rapid multiplication under favourable conditions.

The Bombay Locust is endemic in the region of the Western Ghats and usually visits the neighbouring districts of the Bombay Presidency. In years of multiplication, its swarms invade Kathiawar, Central India, Central Provinces, Hyderabad, parts of Madras, and sometimes as far as the United Provinces, Bihar and Bengal. It is also known to be present in the Laccadive Islands. Buchanan (1807) has recorded the flight of a swarm in Mysore in the year 1800, and during the last century, swarms are known to have been present in 1835–1845, 1864–1866, 1878–1884, and 1901–1908. It is thus seen that it has been active only during comparatively short periods during the last century, but small swarms are known to have been seen also in certain years during the intervening periods. Since 1910 till the present time, however, no serious outbreak has occurred, and in the present imperfect state of our knowledge of its ecology and bionomics, it is difficult to account for its present quiescent condition.

The locust *par excellence* of India, whether judged by the frequency of its visitations or by the extent of its attacks, is the Desert Locust though it is the northern parts of India that are

mostly subject to its ravages. It is usually found in the desert regions of north-west India, but in years of mass-multiplication may invade many other parts of India, up to Assam in the east, and right up to the northern districts of Madras in the south. As this species has been the subject of special investigations in India since December 1930, much information has been gathered in regard to its prevalence in India in the past since the beginning of the last century, from which it is possible to make some observations on its periodicity.

Periodicity of the Desert Locust in India

Data on the occurrence of locusts in India up to 1870 have been gathered from Cotes' Report on the North-west Locust and from various provincial gazetteers and are decidedly scrappy, but from about the year 1870, when season and crop reports began to be published in various provinces, definite information as to the occurrence of swarms is obtainable.

Period 1800 to 1860

Cycle.	Year of occurrence.	Provinces affected.
I Cycle ..	1803	Infestation in Cutch.
II Cycle ..	1810–1813	Swarms in Kathiawar, Rajputana and Bengal.
III Cycle ..	1821 1826	Swarm breeding at Etawah in U.P. Locusts in Kathiawar.
IV Cycle ..	1833-34	Swarms in Kathiawar, Cutch and Rewa Kantha.
V Cycle ..	1843 1845	Breeding in Rawalpindi. Swarms in Panchmahals.

No information about locusts in India between 1845 and 1860, but locust swarms are known to have prevailed in 1855 in Egypt.

From the table on page 10 it is seen that there have been roughly about seven locust cycles, lasting 5 to 9 years each, from the year 1860. When locusts appear, they are seen at the same time in many parts of India, either breeding or migrating, the extent of spread being considerably greater in years of high

Period 1860 to 1940

Cycle Period.	Years of infestation in India.			Years of infestation outside India.					
	Baluchistan and N.W. India.	Cutch, etc.	Eastern India.	Iran.	Palestine.	Egypt.	Arabia, Red Sea.	Algeria.	Kenya.
(1) 1860–1866 ..	1860–62—Sind, Rajputana. 1863—all over.	1860–62 Cutch.	1862 (Monghyr)	..	1865	..	..	1864–66	..
I. Interval in India: 1867-1868 (2 years).									
(2) 1869–1873 ..	1869—All over N.W. India and Cutch 1870 and 1872—Punjab and Rajputana.			1872 (Baln.)	..	1869	1869	..	..
II. Interval in India: 1874-1875 (2 years).									
(3) 1876–1881 ..	All over north-western India.			1876 (Jask) 1881	1878	..	..	1876–78	..
III. Interval in India: 1882–1888 (7 years).									
(4) 1889–1898 ..	All over North India. Swarms reached the south in 1890.			1890, 1897, 1899	1890–92, 1899	1890	1889, 1890	1890–93	1898
IV. Interval in India: 1899 (1 year).									
(5) 1900–1907 ..	All over northern India.			1901–03	1902, 1904, 1908	1903-04	..	..	1901–09
V. Interval in India: 1908–1911 (4 years).									
(6) 1912–1919 ..	All over the north.			1913–16	1915	1914–16	..	..	1914–16, 1919
VI. Interval in India: 1920–1925 (6 years).									
(7) 1926–1931 ..	All over northern India: Reached the south in 1930.			1927–31	1928-29	1928–30	1928–30	1927–31	1928–30
VII. Interval in India: 1932–1939 (8 years).									

multiplication than in those in which only light breeding has occurred. On the other hand, during the intervals between locust cycles, few locusts are noticeable anywhere in India. The swarm-free intervals appear to have been usually short, but in three cases, namely, 1882–1888, 1920–1925 and the last one 1932–1939, they have been fairly long.

During the continuance of an outbreak, the activities of locusts are easily noted and reported, as they always move about in the form of large swarms. On the other hand, during the swarm-free periods, the presence of locusts cannot be easily detected, as they exist then, if at all, only in the form of individuals. All past records have reference, therefore, only to swarms noticed during years of locust incidence, and the information regarding swarm-free intervals is mostly an absolute blank.

During the recent swarm-free period—1932–1939—investigations were in progress under the scheme of locust research financed by the Imperial Council of Agricultural Research, in the course of which particular attention was paid to a study of the habits, ecology and distribution of the non-gregarious locusts found in the desert areas in greater or smaller numbers. Close observations made during this period have shown that, far from disappearing from the Indian area, the desert locust has been existing in the desert areas of Sind, Baluchistan and Rajputana, distributed among the scanty vegetation as scattered individuals mostly in the solitary phase. Continued watch on its movements and activities in all parts of its habitat has shown that it reacts to changes in the environment exactly in the same way as the *gregaria* phase locust. Its breeding is similarly dependent on favourable rainfall, and it migrates over long distances at the change of the seasons from one rainbelt to another, and goes through at least two generations in a year, one in winter-rain areas and the other in summer-rain areas. The main difference would appear to lie in the crowded life lived by the *gregaria* locust and in the high intensification of its activities under the influence of mass psychology. In the present state of our knowledge, the change in status of an apparently innocuous, obscure and sparsely distributed resident of the desert into a highly dreaded pest capable of appearing in vast hordes and dealing whole-sale destruction to crops, would appear to be due mostly to its reaction to a complex of meteorological factors favouring its breeding under crowded conditions.

Another fact of great significance is the circumstance that, whenever the desert locust assumes pest conditions, its swarms appear not only in the Indian area, but generally also in other regions subject to its incidence. During the last cycle, its swarms were active not only in India, but also over Iran, Iraq, Arabia, Egypt, Palestine, Algeria, Morocco, Sudan, and French West Africa. A more or less similar occurrence was observed during the earlier cycles: 1912–1919, 1900–1907, 1889–1898,

1876–1881 and 1869–1873. This possibly indicates the existence of certain common factors in this vast area, which conduce to the appearance of swarms almost simultaneously all over this area. In all possibility, this may be attributed to a general similarity of physical conditions met with over most of the region subject to its incidence, partly owing to the fact that it is part of a great semi-arid zone extending from the west coast of Africa to Central Asia, and partly because each of the three zones of locust habitat of this great area is composed in part of a belt coming under the influence of winter depressions and in part of another falling under the regime of the summer monsoons.

The General Course of a Locust Cycle in India

A fair amount of information is on record regarding the duration of the different outbreaks, the damage caused and the extent covered by the invasions since 1869, but it is only during the last cycle (1926–31), and especially during the years 1929 to 1931, that fairly detailed data have been available for examination. As a result, it has been possible to make a fairly close study of the various factors that were operative (1) in bringing this outbreak into being, (2) in contributing to its progress during the different seasons from year to year, and (3) in bringing about its eventual breakdown. The results of this study have, moreover, served to give a clue to the correct interpretation of the incomplete data available for the earlier visitations.

At the time of the last locust outbreak, there was no definite information available as to where the locust swarms came from, what direction they generally pursued, or what ultimately happened to them. The view commonly held was that most of the swarms were derived from a western source beyond the limits of India and that they generally pursued an eastward direction in the Indian area, where they ultimately died down after a few seasons of breeding.

A close study of the data of swarm movements gathered during the last visitation has served to give us a fair idea of the general activities of swarms in the course of a locust cycle. The general sequence of events during a year of locust swarm activity may be roughly classified under (1) over-wintering, (2) spring breeding, and (3) summer breeding.

Over-wintering: During the winter months, swarms are usually inactive and the locusts generally pass the cold weather scattered among the vegetation. When, however, any warm spells occur during winter, the swarms may make short migration flights from place to place.

Usually very few locust swarms remain in the desert areas of Rajputana, though in years of heavy or late breeding, some over-wintering may occur. The usual areas of over-wintering

are situated in southern Mekran and Lasbela, and in parts of Sind and Kachhi, and sometimes in southern Punjab.

Spring Breeding: With the reappearance of warm weather, swarms become active once again. If good rainfall occurs in January, locusts attain sexual maturity early, and may begin to lay eggs in the areas of over-wintering in February. In any case, swarms begin to migrate north up the hill-valleys as the season warms up, and may lay eggs wherever conditions are favourable during March and April.

In the Baluchistan area, swarms migrating north and north-east from the coastal plains of British and Iranian Mekran reach Kharan and Chagai in March-April, and, by May, they may enter Shorawak and Kandahar in Afghanistan and Sarawan and Quetta-Pishin in the uplands of Baluchistan. Ultimately, the swarms may reach the Kurram and Dera Ismail Khan areas of the N.W. Frontier Province by the end of May or early June. Similarly locusts, over-wintered in Kachhi and north Sind may work their way in spring up the hill-valleys of Mula, Bolan, Nari and Harnai, to reach the upland districts of Sarawan, Quetta-Pishin and Loralai districts by April-May. In the Punjab, swarms migrate in spring from district to district and may lay eggs wherever the situation is favourable.

The adults of the spring brood are ready for flying from the southern areas of breeding by April, and from areas further north by May or June. As by May and June, the interior of Baluchistan and southern Iran becomes an area of severe summer drought, the adults of the new generation begin to leave the areas where they bred, and are gradually carried by the prevailing winds eastwards into the Punjab, Sind and Rajputana, which they reach during June-July in successive waves of migration.

The new generation produced in the breeding areas in the Punjab and western United Provinces also migrate in May-June, the prevailing west wind carrying them eastwards into Central India, Bihar and Bengal.

Summer Breeding: By the middle or end of June, the monsoon current begins to enter north-west India, and the prevalent winds on the Indo-Gangetic plains become easterly, so that gradually all the swarms reaching eastern India are gradually found shifting westwards into western United Provinces, the Punjab and Rajputana by July. With the fall of good rains, the swarms begin to deposit their eggs in these areas. If good rainfall should occur in August and September, these swarms may lay a second and even a third batch of eggs. Moreover, the first adults of the monsoon brood usually are ready to fly by the middle of August, and these locusts are also generally able to lay eggs by September-October in the event of good rainfall, from which the adults of the second generation would emerge by the end of October or early in November.

The monsoon usually withdraws from the plains of north-west India by the middle of September, following which the desert areas of Rajputana, and to a less degree the surrounding areas of Sind and Punjab, temporarily develop into areas of drought combined with high day-temperatures. Apparently, these conditions are disliked by locust swarms, which show a tendency to leave the Rajputana areas at this time. In September and the early part of October, south-west winds still prevail in the desert and may carry the swarms north or north-east into the Punjab and United Provinces, whence the general trend is towards south-east. By the middle of October, north-east winds begin to prevail in Rajputana and may carry the swarms southwards into Kathiawar and Cutch or westwards into Sind, Baluchistan or south-western Punjab.

It has been found that swarms flying eastwards into the United Provinces, Bihar, Bengal and Assam, and southwards into Kathiawar, Bombay, and Central Provinces, in the autumn and winter months are not able to reach areas, where spring breeding is possible. Usually, most of these swarms die out ultimately. On the other hand, swarms migrating westwards into Sind and Punjab eventually move on into Baluchistan and Iran, where they begin to breed with the fall of winter rains.

Causes of Breakdowns: From the above facts, it is evident that in the Indo-Iranian region of locust outbreaks, the possibility of infestation being carried to the following year is dependent mostly on the extent to which swarms produced in the eastern areas in summer are able to reach the winter-rain zone. In 1928 and 1930, for instance, the westward migration of swarms in autumn was negligible, and very little of over-wintering was noted in the areas of southern Mekran and Iran in the winter of 1928-29 and 1930-31. The observations made by Predtechensky (1935) in the Persian area indicate that the comparatively small number of swarms that reached the Indian and the Persian areas in the spring of 1929 and 1931 were largely derived from extra-Indian sources—mostly from the direction of Oman in east Arabia. If this contingent had not arrived it is possible that a breakdown might have occurred in 1929 and 1931.

Another very important cause of the breakdown of the infestation is a failure of, or at least a serious defect in, the seasonal rainfall, sometimes in areas of winter precipitation and sometimes in those of summer rainfall, leading to a considerable decrease in the numbers of locusts. When a failure of breeding occurs both in winter and in summer, the locust cycle would naturally come to a sudden close.

On the other hand, favourable rainfall would result in a conspicuous increase in the numbers of locusts. In the monsoon areas, fairly well-distributed rainfall during the months of July, August and September, will lead to prolonged breeding, including

the production of a fairly large second generation, so as to bring about a high multiplication of locusts and a widespread dispersal of swarms in the different parts of India. A similar breeding followed by high multiplication would also result if there should be well-distributed rainfall in the winter-rain areas.

History of the cycle of 1926–1931: Tracing the course of the last locust cycle, we find locust swarms suddenly appearing in 1926 after an absence of six years. The origin of this cycle will be considered at a later stage, but the chief factors in the production of the new cycle would appear to be high winter rainfall in Mekran followed by prolonged and heavy summer rainfall in the desert areas, leading to protracted breeding especially in the southern areas of the desert.

1927: In the winter of 1926-27, west-bound migration of swarms was greatly in evidence, and there was much over-wintering. Spring breeding was heavy in the Punjab and Baluchistan in 1937. Summer breeding occurred in the Punjab and in Rajputana, but was, on the whole, moderate. Westward migration in autumn led to heavy over-wintering in the Mekran areas.

1928: Following good rainfall, there was extensive spring breeding in Baluchistan. Heavy summer migration occurred, but the monsoon rainfall was not well distributed, summer breeding occurred only in parts of Rajputana and the Punjab, and was on the whole light. Little of west-bound migration was noticed in the autumn.

1929: In the winter of 1928-29, there was no over-wintering of swarms in Mekran or Kachhi. Some swarms derived from over-wintered concentrations in the southern coast of Iran and in Oman reached Mekran, Kharan and Chagai at the end of March and in April, but did not lay eggs in these areas as there was no rainfall. They passed on to Sarawan and Quetta-Pishin in May and laid eggs in large concentrations as good rainfall had occurred here in consequence of which very acute infestation resulted here in May-June. Other swarms passed on to Dera Ismail Khan and the Punjab areas in May, but there was little oviposition on account of defective rainfall. The new generation produced in the uplands of Baluchistan and Iran reached the Punjab, Sind, Rajputana and the United Provinces in July and August, and the heavy rainfall then received induced intensive multiplication in these areas.

In the autumn months, swarms migrated south-east into Central Provinces, south into Kathiawar and Gujarat, and west into Baluchistan. The westward movement was specially pronounced, and enormous swarms passed over Lasbela and Baluchistan in the direction of Iran, and masses of locusts are known to have been drowned in the sea along the Mekran coast.

1930: In the winter of 1929-30, heavy over-wintering occurred in Sind, Punjab, Kachhi and many parts of Baluchistan.

Good rainfall was received in January-February in Baluchistan and Punjab. Extensive breeding occurred in the Kech and Panjgur areas in February-March, and in other parts of Baluchistan in April-May. Heavy spring breeding also occurred in the Punjab and United Provinces.

The resulting swarms migrated from Baluchistan in April-May eastwards into Sind, Punjab and Rajputana, whereas the Punjab swarms entered Central India and Bihar. With the appearance of the monsoon rains, breeding was set on foot in the Punjab, United Provinces and Rajputana, but as there was little rain in August and September, breeding terminated early and most of the swarms migrated eastwards into Bihar, Bengal and Assam, and southwards into Gujarat, Bombay and Central Provinces, reaching as far south as Warangal in Hyderabad State. There was very little of west-bound flight in autumn.

1931: Over-wintering swarms were not found anywhere. No locusts were noticeable in the Indian area, until small swarms of Oman origin (according to Predtechensky—1935) began to appear in Chagai in April from the direction of Iran. These swarms bred to a slight extent in Chagai, Sarawan and Quetta-Pishin, and penetrated as far as Kurram in June. The spring generation from Baluchistan migrated into Sind, Punjab and Rajputana in June-July. Monsoon rainfall was, however, not well distributed, and there was comparatively little breeding except in central and southern Rajputana where heavy falls were received in August. Summer-bred swarms were, on the whole, few compared with previous years, and in autumn most of them became dispersed, some towards the east, others towards the south and the rest towards the west flying into Sind and Baluchistan.

In 1932, the winter rains proved a failure in Baluchistan, so that there was no spring breeding, and the summer migration was limited to a few small groups of pinkish individuals, which were noticed on the Mekran and Lasbela coasts and in Sind in June. No swarms appeared and the cycle of 1926–1931 came to a definite close.

We thus see that the continuation of the outbreak in the Indo-Iranian region from year to year during the period 1926–1931 was not a simple case of a succession of seasonal broods, but a complex matter in which several independent factors were concerned. The development of the infestation is dependent on a chain of events which are severally affected by the character of the winter and summer rainfall, the conditions of humidity and temperature and the timely prevalence of seasonal winds necessary for carrying the swarms from one rain-belt to another. If one link or other in this chain of events is broken, a partial or even a complete breakdown may result. In fact, in the spring of 1931, there were no over-wintering swarms either in British or in Iranian Mekran, and a complete breakdown might

have occurred if swarms from the Oman area had not come into Baluchistan in April. Ultimately, the cycle came to a close as the result of poor breeding in the monsoon areas in the summer of 1931 followed by a failure of winter rains in the Mekran area.

Origin of Locust Cycles in India

Although tolerably full information is on record as to the progress and development of the recent locust cycle year by year, there is no clear evidence to indicate how the cycle originated for the simple reason that interest was taken in the locust outbreak only after swarm flights had commenced in the autumn of 1926. It might have been possible to gather full information only if the desert breeding grounds of the locust had been kept under observation during the swarm-free period of 1920–1925. On the other hand, the interval that followed the last cycle was under continued observation by the staff of the locust research scheme of the Imperial Council of Agricultural Research and the results of the studies carried out by them have been found to be of much help in the interpretation of the scanty data collected for 1926. They have shown that in the intervals between locust outbreaks the desert locust reverts to its solitary phase and is found existing in the desert breeding grounds in small numbers in a non-gregarious condition. Except for the circumstance that it does not live a crowded life, the solitary locust has been found to react to changes in its environment in much the same way as the *gregaria* phase locust. It breeds similarly after rainfall and migrates with the change of the seasons, but with the difference that its activities are not so intense.

In a study of the ecology of the solitary phase, the main problem is to determine the conditions in which groups of solitary individuals become transformed into gregarious swarms capable of dealing destruction to cultivation. In the course of the period, 1932 to 1939, several instances of such a transformation of phase were detected in the Mekran area, mainly caused by locust individuals migrating from the coastal areas in spring and early summer and concentrating in suitable patches of cultivation in the interior valleys for purposes of feeding and egg-laying. Since eggs are generally laid under crowded conditions, the hoppers hatching therefrom tend to get crowded and form incipient hopper bands which subsequently develop into the primary swarms of fliers. Such situations as these, where phase transformation is brought about, are termed 'outbreak centres'. In June-July 1935 specially important outbreak centres were observed to have developed in Mekran and to have been instrumental in great part in bringing about a widespread locust incursion into Sind, Rajputana and Baluchistan in July-August 1935. The forms of which this incursion was composed, included a large proportion of the *transiens* and *gregaria* phases, and it is

practically certain that in case fairly heavy rainfall had occurred during the months of August and September in the Rajputana desert areas, these migrants might have bred extensively and developed into true *gregaria* swarms.

In the light of the above observations, the origin of some of the past locust cycles may now be examined. Taking the most recent case first, the following observations may be made.

1940 Outbreak: Since the closure of the locust research scheme of the Imperial Council and the taking over of the work of locust surveys in the desert on a comparatively limited scale by the Locust Warning Organization under the control of the Imperial Entomologist, in April 1939, important locust developments would appear to have occurred, ultimately resulting in the recent reappearance of swarms after an interval of over eight years. From the data contained in the monthly reports of the Locust Warning Organization since April 1939 (for which I am indebted to the Imperial Entomologist), the following tentative hypothesis is presented as to the probable sequence of events that had brought the new outbreak into existence. The final conclusions would, of course, have to be based on fuller data, including details of the biometrical facies of the populations and further information about the distribution of rainfall.

The rainfall received in the winter-spring season of 1938-39 in Mekran was fairly heavy and prolonged, and apparently led to concentrated breeding in the interior of Mekran and Upper Baluchistan including Kachhi during April-June 1939, but as the initial migrant population in the winter of 1938-39 on the coastal areas was very low, the multiplication was apparently not high enough to function as outbreak centres. The monsoon rainfall in the desert areas was more or less a failure except in the northern areas, where light breeding occurred, and the locusts bred here entirely migrated out of the desert by December.

The winter rainfall of 1939-40 in Mekran was moderate and the light population found at the end of winter in Mekran bred first on the coastal reks and at a later stage in the interior, but not to such an extent as to cause outbreak centres to form. In June, however, a light pink swarm was, according to an unconfirmed report, seen near the Iran borders in the Panjgur area—rather significant if correct. Summer migrants were first noticed in the Rajputana desert areas in June. The monsoon began early in the month of June, but the rains were not general but fell in scattered though fairly heavy showers. Owing to the drought which had occurred in the year preceding, most of the vegetation was apparently parched up except in those places where early showers had fallen, and it may be presumed that the migrants from the west were forced to concentrate on such green patches for food and breeding. This possibly led to the formation of the initial outbreak centres in the desert in June-July. It is also stated

that sample populations collected in south Bikaner and at Barmer in the first fortnight of July showed a preponderance of *transiens* and *gregaria*, similar to the facies of the incursion migrants found in July 1936 in Rajputana. With the passage of depressions from the Bay of Bengal over Rajputana, heavy rainfall occurred in August in several places in the desert, and various loose groups of locusts present in the eastern parts of the desert were possibly carried towards the west or south-west by the rainstorms and forced to concentrate in the desert. It is also likely that the adults from the early batches of egg-laying in June and early July were also partly included in the concentrations mentioned above. During visits paid at the beginning of October large numbers of black and yellow *gregaria* hoppers of the 4th and 5th stage are said to have been found in the west Bikaner and east Jaisalmer areas and in the Chachro area. Bands of very young hoppers are also said to have been found as well as numbers of adults concentrated in patches of cultivation. The swarms reported in the second fortnight of October in north Sind, eastern parts of Baluchistan, the south-western districts of the Punjab and in Bahawalpore State, as well as in Delhi, Gurgaon, Hissar and Muttra areas were doubtless derived from the infestations mentioned above.

The Locust Outbreak of 1926: In January 1926, widespread and heavy rainfall occurred both along the coast and in the interior of Baluchistan. Extensive breeding is presumed to have taken place in February-April, and in May-June, local records show that large bands of hoppers appeared in the Kulanch area, and that swarms of pink locusts were met with in June, and found disappearing from the area subsequently. Similar locust infestation would appear to have been noticed also in parts of Kech and Kolwa valleys. These were evidently of the nature of incipient swarms which had been produced from a concentrated breeding of migrants from the coastal reks.

Locust swarms reported to have been found in Kachhi by the end of June and in Sibi early in July were presumably derived from the interior of Baluchistan and possibly also Iran. On the analogy of the incursion of 1935, it is very likely that similar incursions of migrant individuals had reached south-west Punjab, Sind and Rajputana and had begun to breed with the fall of good rain in July. Swarms reached the Lasbela area in August, and breeding commenced in that area with the heavy rain received at the end of August and in September. In the Rajputana desert areas, breeding continued in August and September, and with the passage of depressions across the desert, locusts apparently became more and more concentrated in the south-western parts of the desert, where heavy breeding was noticed in the Thar and Mallani areas in September-October. Pink swarms produced here began to invade Kathiawar, Sind, Baluchistan and the Punjab between October and December. In

1926, the earliest swarms were found in south Sind, whereas in 1940, the earliest swarms flew north-west and reached the southern districts of the Punjab. This was presumably because the bulk of the breeding was in the northern parts of the desert in 1940.

The Outbreak of 1923: Records of the Naib-Wazir, Turbat, show that large hopper bands were detected in April-May in the villages of Zarenbug and Hassadi in the Dasht River valley and that control measures were taken by the local authorities. By the end of May, the infestation reached Gabd and practically extended all over the valley, and by June the adult locusts disappeared from the area. In July locusts were reported from the Kachhi area, and presumably others migrated into the desert areas about the same time, but apparently swarming did not occur in summer.

The Origin of the Cycle 1912–1919: In 1911, incipient swarms are known to have been observed in the Dasht valley in early summer, presumably as a result of good winter rains and especially of good falls in March recorded all over Baluchistan. Breeding is also recorded in the Kachhi area in April-May. As the monsoon proved a failure all over the desert areas in June, July and August, there was little scope for breeding in summer. The winter rains of 1911-12 were light to moderate in Baluchistan, but the monsoon rains in the desert began early in June, 1912 and were fairly heavy and well distributed. In July and August, there were good falls in most places, and in south Marwar, there were some showers even in September. Prolonged breeding including the production of a second generation would appear, therefore, to have taken place, especially in the southern parts of the desert. The first swarms were noticed in the Thar area in September and numerous flights invaded the south of Sind and Mekran in October, November and December. The swarm formation of 1912 very much resembled that of the present outbreak, inasmuch as it immediately followed a year of summer drought in the desert.

Cycle 1900–1907: The year 1899 was a period of severe drought in the Rajputana desert area, and very few swarms were seen that year. Good rainfall occurred in the winter-rain areas in 1900, and was followed by good monsoon rains in the desert, as a result of which swarming started again in the desert and pink flights commenced in September-October, 1900, in Rajputana and Sind and reached Baluchistan and the Punjab in November-December.

Cycle 1889–1898: This cycle was preceded by a long break—1882–1888. In 1888, good winter rainfall would appear to have occurred, but the only evidence about the appearance of locusts is the record in the Sind Season and Crop Report of 3 swarms in July in the Hyderabad area. Presumably, some summer breeding had occurred in the desert of which there is no record. The

winter rainfall of 1889 was also good, and swarms began to appear in the Punjab, Sind and Rajputana areas as early as May. The monsoon was also early and rains began at the end of May, and continued till the end of August as a result of which extensive breeding took place.

Cycle 1869–1873: The year 1868 was a year of drought in Rajputana. The winter of 1868-69 was a wet one, and swarms would appear to have reached S.W. Punjab early in spring, and Rajputana in June. Heavy breeding occurred in the desert in July-August, and swarms appeared in the Thar area by the 15th September.

The data mentioned above would indicate the importance of the following sequence of events in originating a new locust cycle: (1) heavy and well-distributed rainfall in the winter rain areas in causing the formation of outbreak centres in the interior valleys of both Iranian and British Mekran, and bringing into existence the nucleus of future outbreaks, (2) the conveyance of these incipient swarms into the desert area at the right time for bringing about monsoon breeding, and (3) the occurrence of heavy and well-distributed monsoon rainfall to bring about concentrated and continuous breeding in the desert for building up large swarms. There would appear to be some reason to consider that summer droughts in the Sind-Rajputana desert have probably the effect of creating patchiness of vegetation at the beginning of the succeeding year's rainfall, which is perhaps instrumental in causing the initial concentrations of locusts resulting in incipient swarming.

The Importance of Checking the Initial Outbreaks

At the last International Locust Conference held at Brussels in 1938, stress was laid on the importance of keeping under surveillance the areas known to be responsible for starting fresh outbreaks of locusts and of controlling the incipient outbreaks before they got out of control. The experience of past locust outbreaks has shown that it is difficult to bring locust infestations under control, once the swarms have begun to fly about and migrate to distant places. The best way of dealing with them would be to locate the centres of outbreaks and destroy the incipient bands of hoppers before they are in a position to acquire wings and leave the area. In the Indo-Iranian area of infestation, the primary outbreak centres are formed in the winter-rain areas—within the limits of British or Iranian Mekran, and perhaps also of eastern Arabia, where the transformation of phase from *solitaria* into *transiens* or *gregaria* may occur and sometimes even the formation of small, loose, flying swarms. Generally, however, the new generation would appear to migrate as groups of individuals rather than as swarms, as had happened

in 1935, to the summer-rain areas. If conditions are favourable here, small concentrations might be formed in June-July-August, and in case of the occurrence of good precipitation in August or September, the dynamics of the depressions from the Bay may bring about further concentrated breeding in the desert and the building up of large swarms.

In regard to the control of the outbreak centres, the present locust warning organization has been suffering from certain serious handicaps. In the first place, it is only the centres that are within British limits that can be tackled by the staff. As yet no information is available as to whether the co-operation of the Irānian Government has been secured in regard to a joint watch and control of the outbreak areas in the winter rain zone; for, without the simultaneous control of the Iranian centres, much useful purpose will not be served by the measures taken in Mekran only. Secondly, even in the Indian area, most of the outbreak centres are located either in distant hill-valleys in the interior of Baluchistan, or in wide expanses of the Indian Desert, and as most of them are situated in very sparsely populated country lacking means of easy communication, it has been found difficult, on account of the inadequacy of the staff engaged on this work at present, to detect cases of incipient swarming sufficiently early for purposes of control.

The Resolution of the Fifth International Locust Conference on this subject recommended the formation of an organization composed of staff financed by the co-operating governments, whose functions were to be chiefly (1) the permanent supervision of all outbreak areas—whether known or suspected, and (2) the immediate destruction of incipient swarms whenever observed.

The locust warning organization of the Government of India, as at present constituted, was not designed to undertake the control of the incipient outbreaks. Indeed, the present strength of the staff cannot be deemed to be sufficient even to patrol effectively the vast areas of locust habitat for the detection of the danger points in time. Since swarms have now appeared, the indications are that a new cycle of infestation has started, which will mean that further trouble is in store for the cultivator when these swarms begin to breed with the fall of winter rains.

Sunspot Cycles and Locust Periodicity

It is generally recognized that many of the natural phenomena noticed on the face of the earth are ultimately traceable to the energy derived from the emanations radiating from the sun, and it is not surprising that an explanation of the countless fluctuations found in various earthly phenomena, such as the daily weather changes and variations in the growth of

plants and animals, has been sought in the variations in the quality and quantity of solar radiation. Emanations from the sun are, on the other hand, found to vary with the number of the 'sunspots' noticeable on the sun's disc. Sunspots have been described as 'terrific cyclonic storms in the solar atmosphere generating powerful electro-magnetic fields', and the number of sunspots gradually increases for some years and then decreases, a single cycle of such changes being usually of eleven years' duration. Observations have shown that the occurrence of magnetic storms, auroral displays, and the fading out of radio transmissions in some years are all connected with an increase in sunspot activity. Harlan T. Stetson (1937) has shown in his fascinating book on 'Sunspots and their effects from the Human Point of View' that the growth of plant life varies directly with the increase in the number of sunspots, while in the case of animals there is an inverse variation. Swinton (1880) has adduced evidence to show that periods of prevalence of locusts generally coincide with those of sunspot minima, while Criddle (1932) found that outbreaks of grasshoppers in Manitoba (Canada), coincide with periods of sunspot minima, and Richmond (1938) also found a similar coincidence in British Columbia. Uichanco (1936) found a fairly marked negative correlation between solar activity and locust fluctuation in regard to the swarms of the Migratory Locust (*Locusta m. manilensis*) in the Philippines.

As, in the case of the cycles of infestations in north-west India, fairly detailed data were available since 1860, a graph was worked out showing the fluctuation in the infestation, based on the comparative extent of damage, the area of spread and the degree of oviposition, and superimposed on a graph of sunspot numbers for the corresponding period (Rao, 1938). The result was that a general negative correlation was found to be existent between the sunspot curve and the curve of infestation, except at two places, viz. 1905–07 and 1928–31. It was also evident that in almost all cases where a new cycle began after a break, the incipient swarms were mostly produced during the period when sunspots were either at their minimum or low in numbers.

It is rather difficult to imagine how sunspots could have any direct action on locusts unless the emanations from the sun can be deemed to have a prejudicial effect on their reproductive powers. On the contrary, the locust is entirely dependent on the occurrence of optimum weather conditions, especially favourable rainfall in the winter and summer rain-belts, for its multiplication, and since the world climate is ultimately dependent on the quantity and quality of solar radiation, it is quite conceivable that locust incidence may be indirectly affected by the fluctuation of sunspot activity.

The Need of further Research on Locusts in India

At the present moment when a fresh swarming of the desert locust has begun after an interval of over eight years, it would be useful to make a retrospect of the results achieved since the last great outbreak. At the time of the commencement of the last cycle in the autumn of 1926, when large swarms similarly appeared after an interval of over six years, our knowledge as to their origin and as to the factors affecting their movements and breeding was but limited.

In consequence of the widespread damage caused by locust swarms in India, western Asia and Africa during the last cycle, various research schemes were inaugurated in different countries and were in progress during the last decade; and as a result thereof a decidedly large advance has been achieved as regards our knowledge of their bionomics, ecology, breeding grounds, general movements and phase transformation.

In India, investigations were in progress since December 1930 under the scheme financed by the Imperial Council of Agricultural Research. As a result of intensive studies of the bionomics of the locust under controlled conditions at Lyallpur under the direction of Khan Bahadur M. Afzal Husain, very valuable information has been obtained in regard to the effect of various factors such as temperature, humidity, muscular effort, the proportion of carbon-dioxide in the atmosphere, etc., on the coloration and phase development of hoppers.

In regard to the search for 'the permanent breeding grounds' of the locust, invaluable information has been secured, showing that during swarm-free intervals (1) it lives as a solitary locust in the desert areas of Sind, Baluchistan and Rajputana, (2) regularly breeds in spring in the western winter-rain areas, and in summer in the monsoon areas in the east, being possessed of the ability to migrate from one rain-belt to the other at the change of the seasons, and (3) assumes the *gregaria* phase as the result of crowded breeding in ecologically favourable situations in the winter and summer brood areas, and of a rapid succession of generations following favourable rainfall.

The practical aspect of this knowledge lies in the fact that the locust is a perfectly harmless insect so long as it does not breed under crowded conditions and assume the swarming stage, and that it is fully possible to prevent it from breaking out into swarms if the *outbreak centres* are kept under watch and any incipient outbreaks that may be noticed are immediately controlled by the requisite staff. It is evident that once locusts are allowed to form into swarms they will migrate long distances and spread over a wide area, and it would then be difficult to control them except by adopting extensive measures at great cost and expense in the various provinces affected. It would, therefore, really be a kind of crop insurance to maintain a

competent staff provided with the requisite funds and material to watch the locusts in the desert areas and control the initial outbreaks as soon as they are detected.

It is, however, a tragedy of life that the human mind is generally unable to assess danger at its full value unless it comes actually face to face with it. While a locust infestation is in progress and swarms are actually making their presence felt, the public as well as the government are ready to spend vast sums of money to control the pest and are anxious to provide for scientific investigations to find out all about the activities of the insect. When, however, the outbreak subsides and the locusts disappear, all interest in the investigations in progress is lost in course of time and work is stopped before any legitimate conclusions can be reached. The observations made in the African and the Indian areas had clearly indicated the necessity of immediately dealing with incipient swarms for controlling a new outbreak in its early stages, but unfortunately the staff and the funds allocated for the Locust Warning Organization were obviously inadequate to enable it to control incipient swarming at the critical time. Numerous swarms have already appeared in rich agricultural areas, but by taking the necessary control measures, it should be possible to prevent it from developing into another cycle of locust menace.

Although a considerable advance has been made in a study of locust epidemiology, there are still various gaps in our knowledge of locusts, especially in regard to problems of a fundamental nature, and it is hoped that it would be possible to get the necessary funds for their investigation while material for study is available during the present swarm period.

Besides the Desert Locust, in the case of which, thanks to the funds generously provided by the Imperial Council of Agricultural Research, a great deal of essential knowledge has been acquired, there are two other locusts which are potential enemies of the agriculturist in India, about which little is known as to the exact conditions in which swarm formation takes place.

First, we have the Bombay Locust—*Patanga succincta* L., which is one of the serious locust pests of India. In the past, India has experienced several infestations, of which, however, we have detailed records of damage only in the case of the last two visitations, 1878–1884, and 1901–1908. The last outbreak of this locust was in full swing when the first Entomologist to the Government of India—the late Prof. Maxwell Lefroy—arrived in India and took up his duties in 1904 and the investigations carried out by him cover a great extent of ground. But, in the light of the locust lore of modern times, the problem of the Bombay Locust will have to be examined afresh, especially in regard to the location of its permanent breeding grounds, an investigation of the bionomics and ecology of the solitary phase

and the determination of the factors that have contributed to its comparative quiescence for the past thirty years nearly. This is all the more important, because the staff engaged in the surveys of the desert locust in the Rajputana desert areas have been finding every year solitary specimens of the Bombay Locust during the autumn and winter months in many places, though so far its hoppers have not been found anywhere in the desert, and there is little doubt that they form instances of long distance migration. Past records show that its visitations had descended rather suddenly on the public without a warning, and it would not redound to the credit of India if, sooner or later, Peninsular India all at once finds itself at the mercy of the marauding swarms of this locust. At present no attempt has been made to study the problem while the insect is in its solitary phase, and there is no organization to keep a watch over its developments and to check the outbreak in its initial stage.

Secondly, there is the Migratory Locust. Although it has generally been found in its solitary phase all over India, past experience has shown that it can, under favourable conditions, increase in numbers to such an extent as to assume serious pest conditions. In 1878, this insect invaded district after district in the southern parts of Madras, usually so free from the importunate attentions of locust swarms, but fortunately it relapsed into its usual status of a harmless grasshopper by the end of the year. In 1937, this insect was reported to be doing extensive damage to crops in October in Sirohi State and in the States of Kathiawar and Gujarat, and if its earlier activities in that year had not been traced by the Locust Survey staff, one would have thought that the infestation was only of local origin, whereas actually it originated in the hill-valleys of Baluchistan and spread into Kathiawar and Gujarat only after passing through heavy breeding in the Bikaner-Jaipur areas in July-August. At present, it is not known whether the Indian form is allied to the Tropical Migratory Locust of Africa or to the Eastern Migratory Locust of China and the Philippines, and it is only when the *gregaria* form is bred out that its systematic position can be determined. It would be of much scientific and practical interest to study it under controlled conditions and find out the causes that provoke its sudden outbreaks.

There are, besides the locusts, certain very injurious grasshoppers in India, which occasionally rear their destructive heads in certain years and occasion a great deal of damage. Of these, the Deccan Grasshopper, *Colemania sphenarioides* Bol., is one of the most important, seriously affecting dry crops over a very large area of Bombay, Mysore, Hyderabad and Madras. This also shows considerable fluctuations in numbers and possibly appears in cycles. Species of *Hieroglyphus* seriously affect both dry and wet cereal crops all over India and *Aeolopus*

affinis is also known to be a serious pest of dry crops in certain years in parts of India.

It is to be hoped that in course of time many of these injurious locusts and grasshoppers, which at some time or other cause considerable losses to the Indian cultivator, would be tackled either by provincial initiative and effort or by schemes of an all-India character, so as to bring relief to the man behind the plough, who, after all, is the man that directly or indirectly supports the whole machinery of Government, though, of course, it is somewhat of a forlorn hope at the present time, in view of the exigencies of war, to expect any considerable support for scientific investigations.

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SECTION OF ANTHROPOLOGY

President :—TARAK CHANDRA DAS, M.A.

Presidential Address

(*Delivered on Jan 4, 1941*)

CULTURAL ANTHROPOLOGY IN THE SERVICE OF THE INDIVIDUAL AND THE NATION

INTRODUCTION

It is my first duty to offer you my sincerest thanks for the honour you have conferred upon me by electing me to preside over the deliberations of this Section of the Indian Science Congress. The subject of my discourse to-day is 'Cultural Anthropology in the Service of the Individual and the Nation'. We, Indians, are now passing through a stage in our national life when a clear statement of how anthropology can help to build up the future of India is not only suitable to the occasion but is an imperative necessity.

Anthropology is commonly believed to be a border-line science which has no practical application. This misconception is due partly to lack of knowledge of the scope of and recent advances in anthropology on the part of the ordinary man and partly to the anthropologists themselves who have in the past laid too much emphasis on the historical side of the subject. But recent trends in both physical and cultural anthropology show a definite change in the angle of vision and the study of the present is seriously replacing that of the past. Professor Le Gros Clark has given us a very clear idea about the applied side of Physical Anthropology in his Presidential Address before the Anthropology Section of the British Association for the Advancement of Science at its Dundee Session in 1939. I do not propose, however, to tread over the same ground again, but intend to confine myself to Cultural Anthropology alone.

Before going to show the place of Cultural Anthropology in the life of the ordinary man of diverse professions we wish to draw attention to one general condition which affects all the different groups equally and which shows how Cultural Anthropology is ultimately connected with them. You are all well acquainted with the law of demand and supply in economics. An institution does not come into existence if it has no necessity for the community in which it flourishes. We hear that this

law is equally applicable in the biological world. Anthropology as a science is of no ancient origin. We may say in round figures that during the last 100 or 150 years at the utmost this subject has developed to its present volume and importance. The history of the world shows that during this period better means of communication arose and the European nations spread over the world and established political supremacy over or commercial connections with diverse races and cultures. This contact between the European races and the coloured peoples of the earth has brought to existence the Science of Man. The early traders, conquerors and missionaries tried to understand the people with whom they came in contact. Every one of them, whether an administrator, missionary, merchant, soldier or planter, required to be sympathetic in dealing with persons of his own or alien race. It has been claimed by one of the early stalwarts of Indian anthropology that 'sympathy is one of the chief factors in successful dealings of any kind with human beings, and sympathy can only come of knowledge. And not only also does sympathy come of knowledge, but it is knowledge that begets sympathy............. Familiarity breeds contempt, but it is knowledge that breeds respect and it is all the same whether the race be black, white, yellow or red, or whether it be cultured or ignorant, civilized or semi-civilized or downright savage'.[1] This knowledge which breeds sympathy was supplied by the men who came to settle among alien people for purposes of business. They recorded the manners, customs, beliefs and superstitions—in a word the life of the people among whom their lot was thrown. This volume of literature forms the bed-rock of Cultural Anthropology. These records are not always perfect for scientific purposes as they are not the products of trained scientists yet they give us the fruits of observation made by the practical men who tried to solve their own difficulties and recorded their experiences to help and guide others who might have to face similar difficulties in their own fields of activities. The deductions of modern Cultural Anthropology are based on these observations of practical men and the subject itself owes its origin to them. This clearly indicates the service which Cultural Anthropology rendered in the past to the different human professions and it may be reasonably expected that it will render the same help in future, perhaps in a better manner as it is more perfectly organized now. So, the Law of Demand and Supply shows that anthropological knowledge was necessary at the beginning of European expansion and the early settlers by recording their experiences among alien races laid the foundation of a science which has already secured a place among its sister subjects and dreams of a future fraught with immense possibilities.

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[1] Sir R. Temple—*Indian Antiquary*, Vol. XXXIV, 1905, p. 133.

We hope, you have already a glimpse of the necessity of cultural anthropology in modern life and it owes its origin to this necessity. But we shall try to convince you further on this matter by a detailed study of the part which this subject plays in the life of the ordinary man.

Place of Anthropology in Trade, Industry, and Agriculture

Trade, industry, and agriculture are the three most important institutions of modern man. Our life and culture depend on them. They are the sources of livelihood of millions of our brethren. Let us see what part anthropology plays, in these three departments of modern culture. Trade is mostly based on industry and agriculture. It means distribution of goods produced by agriculture and industry and the law of demand and supply governs this distribution. 'Who is successful in commerce but he who finds out where the market is, and having found the market, knows how to take advantage of it and what to avoid? In seeking a market, the habits, ways, predilections and prejudices of many kinds of people have to be learnt, and this is the case in a much higher degree in preserving the market when found.' Many a foreign market has been lost by the merchant and the manufacturer through their ignorance of the local people and their pride born of the same ignorance. It is often argued by the manufacturer that he is not going to change the mode of production of a particular article in response to a demand from a foreign market but would stick to the method he found suitable for the consumers in the home market. Nothing is more foolish and ruinous and this had been the case with a number of British firms in the early days according to an experienced British administrator. No one will take a thing which he does not like or cannot pay for whether he be civilized or savage. Among the primitive the prejudice is more strongly felt. 'Beads as beads do not appeal to the savage but it is a particular kind and form of bead that he wants for reasons of his own, practical enough in their way—and so on through every article of trade.' Sylvia Leith-Ross in her *African Women* points out, in this connection, how European commercial concerns consult the opinion of Ibo women traders about the suitability of patterns received from England and introduced in the area. Their views receive serious consideration from these mercantile firms. If you go to the interior of Chota Nagpur, you will find nowadays hundreds of rupees worth of glass beads and bangles being sold to its primitive inhabitants by the local traders. Most of them come from Japan and pass through Calcutta. But only half-a-century ago or even less these glass articles were unknown to them. Lac beads and bangles manufactured in and near about the region by the local people

were in use at that time. Chota Nagpur is reputed for its lac in the world market even to-day but in spite of this the local product could not successfully fight against the foreign article. The secret of Japan's success in this department lay in her minute study of the local taste, demand, and paying capacity. The local producers did not pay any heed to these three factors which constantly change, however minutely, with progress of time and the result is that they have been wholly ousted from the market. Brass and bell-metal industry of Bengal is also faced with the same fate at present. Aluminium utensils are vigorously pushing their way into the rural parts of Bengal and the workers in brass and bell-metal will soon pay the penalty for their neglect.

Dress and ornaments show how taste changes with the passage of time. Social, political and economic factors contribute in a more or less degree towards the formation of fashions of a people. This may be illustrated from a study of the history of even such an insignificant trait as the ladies' foot-wear for the last twenty-five years in Bengal. Post-war impetus to female education, non-co-operation movement in politics and general trade-depression all over the country have operated in the origin and growth of this trait. Numerous instances of this nature may be brought forward and they show what an intimate knowledge of the social, political, religious, and economic life of a people is necessary if you wish to be a successful supplier of goods to them. A false step or a little laxity in the constant watchfulness may ruin the business. This intimate knowledge about a large section of humanity is supplied by Cultural Anthropology and the trader and the industrialist may profitably employ this knowledge to the furtherance of their aims. They may employ young men trained in anthropology to conduct their business in far off countries with instructions to keep their employers informed about even the slightest changes in the life and manners of the people among whom they may be stationed. Many important firms in England have appreciated the force of this argument and now employ such anthropologically trained young men to conduct their business in foreign markets. Indian students of anthropology may also be employed in the same manner by Indian firms though unfortunately their scope is very limited and our mercantile community not so advanced in their ideas. This is, however, a circumstance for which our subject is not responsible. It may be urged that the kind of knowledge noted above can be and had been successfully acquired by men who have or had no anthropological training. 'Granted, but the man who has been obliged to acquire it without any previous training in observation is heavily handicapped indeed in comparison with him who has acquired the habit of right observation, and what is of much more importance, has been put in the way of rightly interpreting his observation in his

youth.' This is how the anthropologist helps the trader and the industrialist and is in turn helped by them.

Besides supplying information to the industrialist regarding the nature of things required by a particular market the anthropologist can help him in other spheres as well. The old days of home-industries are gone. The invention of modern machineries has centralized productions in big factories. This has brought about the struggle between capital and labour which is occupying the attention of all serious-minded people in every country of the West. In India, though the fight between labour and capital has not reached the same degree of acuteness, it is gradually gaining ground. In our country labour is often supplied by the primitive tribes. In the mines and factories of Chota Nagpur thousands of labourers are employed and they are mostly recruited from amongst the tribes which occupy this part of the country. The tea-plantations of Assam are also worked by labourers mostly recruited from the tribes of Chota Nagpur, Orissa and Madras. The treatment which these labourers receive from their employers shows utter ignorance of their life and customs. This leads to lack of sympathy on both sides and consequent misunderstanding. Troubles naturally crop up under these circumstances entailing huge loss of money to the employer and the employed. But this can be easily avoided with a little knowledge of anthropology. Petty grievances which can be removed by a sympathetic master at a nominal or no cost often assume huge dimensions when they are not attended to at the outset.

Big scale farming also involves the question of labour and capital. The planters of Assam and Ceylon employ tribal labour to a very great extent. They try their best to exploit the labourers to the utmost degree and do not make any attempt to understand their difficulties. This unsympathetic attitude is at the root of much human misery which can be easily avoided by a little knowledge. I need not point out that there is much difference between voluntary and forced labour; the worker must feel pride and pleasure in his work; he is to be tuned to offer his services and not made to feel that work is being extracted from him. This psychological attitude is more paying in the long run and this can be achieved only by an intimate knowledge of the life and traditions of the workers, by a knowledge of their past happiness and present difficulties. Anthropology supplies this knowledge more than any other branch of learning. These tribal labourers uprooted from their native soil and planted temporarily in and around work-centres lose practically all contact with their own people. They no longer find themselves under the benign control of their family, clan and village elders, each and every one of which units exercises a very judicious check over the individual inclinations in their homeland. Free from these controlling agencies to whom they always look for

guidance whenever occasions arise these simple men from the hills and jungles fall easy prey to the vices common in such areas. Moreover, they are often misled by wily interested people to commit actions the full import of which they can hardly realize. In such circumstances arise most of the labour troubles in work-centres and it is the duty of the employers to realize the situation and arrange for their redress. Strong measures only toughen the stuff but a little sympathy with more knowledge may easily soften the situation. This is where anthropology brings in practical relief to the producers.

Anthropology in Law and Legislation

Let us now see how anthropological knowledge can help the members of some of our noble professions as for example the lawyer, the educationist, and the missionary. A lawyer practising in a primitive area should know in detail the manners and customs of the people who may come to him for legal advice and help. Unless he is well acquainted with the life of the people he cannot properly represent his client's claims before the judge. The judge also requires an intimate knowledge of the people among whom he has been placed to dispense justice. This is more so in a primitive area. The primitive peoples have different notions of law and their ideas of grievances sometimes differ from those of ours. The law of limitation, as for example, does not exist among some of the Kuki tribes of Assam. When a man borrows money he is to pay it back whenever convenient and there is no hurry on either side. It may be realized from him or from his son or grandson or any other descendant lower down. It is never barred by limitation. Just imagine what a money-lender in such an area thinks of when he hears that the borrower is not required to pay back the loan as it has not been sued for in time according to our custom or law. In Chota Nagpur, again, marriage by force is an established custom among some of the tribes. Nobody thinks it to be a serious crime and cases of this nature are not infrequent in this area. If these cases are brought to the court and punished according to our estimation of the magnitude of the crime it will be sheer injustice. Some magico-religious conceptions also deserve mention in this connection. Belief in witchcraft is a common feature in many primitive areas and sometimes leads to very atrocious crimes by parties of villagers working together. From time to time we hear of murder of old women, suspected to be witches, from tribal areas. The intensity of the crime cannot be realized until and unless we understand the mental and cultural outlook of the people concerned in such crimes. Instances of human sacrifice to different deities in fulfilment of vows or for boons come to our knowledge occasionally from similar areas. The administration of law in these and similar other cases involve a

consideration of the magico-religious beliefs and superstitions of the culprit and his community. At least a part of the responsibility of such crimes lies with the cultural make-up of the people to which the perpetrator belongs. Promulgation of the laws of civilized life among a people of this type without previous education to uplift their cultural condition is unjust and injudicious. As long as the beliefs and superstitions of such a people are not eradicated by education and new values established in their place the laws of civilized life cannot be introduced among them with justice. This shows how the administration of law requires anthropological knowledge even where its sections are clear and the evidences complete to punish the accused. There are innumerable instances of this nature and the lawyer and the judge must be thoroughly acquainted with the people in order to evaluate properly the facts laid before them and their interpretation too. Without this intimate knowledge, both of them may fail to discharge their duties in a suitable manner.

Legislation is a more important field than administration of law for the employment of anthropological knowledge. We all know that most of our laws are codified customs and customs form an important branch of anthropological studies. Primitive society is guided and controlled by immemorial customs and many of them differ in their essential values from our conceptions. We have already pointed out how magico-religious and socio-economic conceptions of these backward peoples differ from those of ours and even a cursory study of any of our primitive tribes will convince you how they have built up their culture round these ideas and conceptions. Under these circumstances introduction of our laws amongst them often tends to maladaptations and consequent decay or degeneration of tribal cultures. Speaking about Africa, Lord Hailey, G.C.S.I., G.C.I.E., one of its greatest administrators, expressed his doubt about the possibility to evolve a homogeneous system of law by reconciling the native customary law with the European law. In the chapters on law and justice and land of his monumental work *African Survey* he points out how conflicting the ideas and interests are in the development of land-tenure and warns the government about all attempts at premature interference especially in this field.

In our own country examples are not rare of hasty legislation which have either proved dead laws (when they are mere permissive) or have definitely been harmful to the whole or part of a community. An instance of the former type is the Widow Remarriage Act which being a permissive law has proved innocuous and has not been able to strike at the root of the evil and solve the problem for which it was intended. If we are to believe, what Mr. J. M. Dutt has shown in the pages of the *Modern Review* (Jan. 1940, pp. 36–41), that enforced widowhood is ultimately responsible for the gradual decrease of Hindu

population in Bengal, then this law should be turned into a coercive one in the interest of national welfare. Here we require the help of the social anthropologist who will point out by intensive investigation the advisability or otherwise of promulgating a coercive law of this nature. Another instance of a futile Act of this type is the Sarda Act of 1929 which prohibits marriage of children. The aim of this Act is evidently to stop marriage before physiological maturity which is the only justification for such a measure against a very important socio-religious and economic institution. But the age of marriage legally allowed by this Act falls far short of physiological maturity. British India even falls short of what has been prescribed by some of the Indian States and readily accepted by its people. Such a measure should have been preceded by a wide and intensive study of its socio-economic implications and the prevailing opinion of the people. Who is better fitted for this task than the cultural anthropologist? There are talks to restrict Hindu polygyny and to introduce divorce amongst them by legislative measures but we are afraid that these also will meet with the same fate which overcame their predecessors in the domain of socio-religious legislation. At every stage in the passage of such Acts orthodoxy clamours unceasingly against these so-called reactionary measures and almost in every case successfully amputates the well-conceived measures and the promoters of the latter are not armed with the requisite facts and figures to fight against the age-old conservatism of our country. The result is a half-way compromise which practically nullifies the original motive of the measures. Such half-hearted actions not only retard future progress but also lull into quiescence the spirits of change and progress.

Society is, as it were, a huge organism. If you strike it at any one point, all its parts feel and react. One should be cautious before he attempts to strike such an organism. The Permanent Settlement of Lord Cornwallis brought about a Hindu landed aristocracy in Bengal in the early years of British rule out of political and financial exigencies. The system of inheritance practised in this part of the country has for the last 150 years gone on dividing these holdings generation after generation reducing their size and income. Thus a large class of petty landholders came into existence. European trade with the development of Calcutta as the most important centre for export and import business with Europe attracted a large number of these small landholders and gave employment to them. Besides this, the conquest of the whole of India with the wealth of Bengal and with Calcutta as the base, provided further employment in government service to a large number of the sons of the same landed community. Moreover, this community realized at an early stage the importance of English education and unhesitat-

ingly gave up the indigenous system in favour of the novel importation and thereby prepared themselves for the part which they have played in the development of British trade and British political supremacy. What they suffered in this new adjustment need not be reiterated here. Suffice it to say that this is mainly responsible for the dismemberment of the Bengali joint-family and the subversion of the land-economy of the country especially in its middle class population whereby thousands lived on the direct products of the land. The strong Hindu middle class which has been brought into existence by requirements of British rule and British trade forms now the pride of the country—a community which has its roots deep into almost every nook and corner of our socio-economic life. The recent recommendations of the majority of the Floud Commission to abolish this permanent settlement naturally raises grave doubts and graver suspicions in the minds of anthropologists about the judiciousness of hurrying into such a step. Such an Act, according to the estimate of the commissioners themselves, will involve directly about two and a quarter millions of Bengal's population. Indirectly it would affect a much bigger number and its stupendous effects on the social and economic life of the province cannot be realized at this stage. Experiences of African experiments should guide our legislators in this difficult situation and I would not hesitate to draw their attention to what has been said by Lord Hailey in comparable circumstances and referred to before in this discourse. A thorough and sifting enquiry by a band of competent social anthropologists in urban and rural centres and among all classes of peoples who are directly or indirectly connected with the problem is necessary to assess the effects of such a revolutionary measure. It is not the task for a Commission composed of persons who have no personal knowledge of or contact with the life of the millions who have been placed at their mercy. Nor is it the task of the economist or sociologist alone but we require one who combines both these sides and something more and that is a sympathetic knowledge.

Owing to improvement of facilities for travel and transport and lack of food and employment in the densely populated areas of advanced countries civilized people have moved and are still moving towards the more backward parts of their own or other countries. This has brought them in contact with the primitive peoples inhabiting the more inhospitable regions of the earth. Besides this, the more intense exploitation of the natural resources of the country by capitalists and business corporations has necessitated the importation of cheap labour to mining centres, industrial works and cash-crop gardens of the different undeveloped areas. And cheap labour is supplied by the tribal peoples. This has brought into existence vast areas of culture-contact wherein the savage and the civilized are nowadays living side by side trying to adjust themselves as far as possible

to each other's cultures. But in this attempt at adjustment the savage has always a losing game to play. He is no match for his wily neighbour who always tries to exploit him in every way possible. The result is the growth of a number of maladjustments in social, religious and economic life of the less advanced and this is undermining the strength and vitality of these people. Here we shall consider only the legal implications of such culture-contact.

India possesses a vast area of culture-contact wherein primitive tribes from neighbouring hills and jungles have come down to live among its civilized peoples. All along the foot hills of the Himalayas we have a vast area of this nature. The border districts of Bengal towards the east form an area of such culture-contact between the Mongoloid peoples of Assam and the Bengalis. A similar area is also met with on the western front of Bengal and this is practically the story of many other provinces of India. Besides these border areas, there are culture-contact regions even in the heart of a number of provinces such as the tea gardens of Assam, the coffee plantations of Madras, the mining districts of Bengal and Bihar, etc. The total population of these culture-contact areas of India runs into several millions, and this sufficiently indicates the magnitude of the problem.

These areas are generally governed by laws which are suitable to the more advanced communities. But this has given rise to a number of maladjustments. We shall consider here only one such case—that of the Garos. A large number of people of this tribe have come to settle in the plains of Mymensingh at its northern boundary just below the Garo Hills. The dominant people here are the Bengalis among whom they have established their villages. The Garos of the Garo Hills are a matrilineal, matrilocal people among whom property is owned by the women-folk and men have no right over it unless it is self-acquired. There is a special system of inheritance by which one of the daughters is selected (*nokna*) to inherit the property of the mother. This system worked quite satisfactorily so long as the Garo stuck to their hill home where temporary hill cultivation is practised. Land, in this area, has no intrinsic value of its own as the same plot does not produce any crop for more than 3 or 4 years at a stretch after which it has to be left fallow for 10 to 20 years to accumulate mould in order to be ready for another cycle of cultivation. The house, another important item of property in the plains where it costs a lot of money, is not of much importance in the hills where the materials are available in the neighbouring jungles without payment and the labour is provided in each case, free of charge, by the villagers themselves. Besides these, that is, land and house, the hill Garo family of ordinary means possesses a few domestic utensils and agricultural implements, most of which are manufactured by the householder himself. Thus the question of inheritance does not loom large in such a community

and the sons of the family easily go over to their wives' place leaving to their selected sister and her husband all the property of the family. Moreover, in such communities, accumulation of wealth in particular hands is a rarity as the system of economy is not suitable to its growth. Under these circumstances the migration of Garo families to the plains of Mymensingh with a different system of land-economy, that is, with permanently cultivated fields and with the possibility of accumulation of money in individual families, has led to a change in the outlook of Garo sons and their fathers. They no longer like the idea of leaving the permanently cultivable land to the *nokna* and her husband and a conflict has come into existence. The recent revenue settlement of the district has brought out the nature and extent of this conflict, and the Department of Anthropology of the University of Calcutta was invited to investigate into this problem. Very interesting facts have been revealed by this study of the Garo law of inheritance in the plains which fully justifies the claims of anthropology in the elucidation of problems of culture-contact.

Africa shows innumerable problems of culture-contact in connection with law and justice in its different areas. At the invitation of the Bechuanaland Protectorate Administration Prof. Schapera studied the laws and customs of the Tswanas and showed that a proper understanding of them depends on an examination of the nature and functions of the political, territorial, kinship, age and class groups. This relationship between different persons and groups form the background of primitive law. Law in primitive society does not depend on State sanction alone but has its roots deep in the life and traditions of the people and stands on sanctions of a very different nature some of which are automatic, others magico-religious and the rest derive their sanctity from public opinion. This is the secret of primitive administration. Without an executive authority or sometimes even a judicial body, law and order are maintained in primitive society as if automatically. This is why we advocate the employment of social anthropologists both in the administration of the old laws and the promulgation of new ones. This is no less applicable in case of advanced communities. Legal measures affecting the economic system of the country are referred, as a rule, to the specialist in that particular branch of economics which is affected by the measures. But this is not the custom in India, at least, when social legislation is attempted The specialist is not consulted but the opinion of the lay public and the whims of our legislators decide the fate of such measures. Moreover, the Government do not possess any information, beyond what is supplied by the Census Reports, on the socio-religious life of the people. I need not dilate on the character of the information supplied by these Census Reports and the nature of their origin as they are well known to all of you. I have

already stated that society is as it were a complex organism and when you strike such an organism at any one part, all other parts respond to it almost immediately. The large number of traits—social, economic and religious—which compose the society are all intimately interlinked and the social scientist has made it his business to study this system of linkage and is thus able to indicate how these links will behave when one of them is affected by a piece of legislation. The opinion of laymen, however erudite and considerate they may be, will at best take into consideration a few aspects of the question which have possibly come under their personal knowledge and not the whole system of linkage. The social scientist on the other hand draws upon the accumulated knowledge of his science and shapes his views according to this knowledge and his own experience and the requirements of the particular case. He also requires help and this in the shape of detailed information about particular problems and general sociological knowledge of the country in which his sphere of work is limited. This leads us to the question of an intensive sociological survey of the country. As social scientists we must arm ourselves with a detailed knowledge of our society scientifically collected by a band of trained men under expert guidance so that we may in turn arm our traders, industrialists, legislators, educationists, social reformers, and administrators, to fight in their respective fields. Society is not a static body; it is always changing and this corpus of knowledge accumulated at a particular period of our national life must be kept up to date by recording the changes constantly taking place in our life. This is how social anthropologists can help the country in the promulgation of new laws and this is where they should be consulted if we wish to avoid dead laws and half-hearted measures.

ANTHROPOLOGY IN EDUCATION

Educating the primitive is a dangerous task: it is beset with numerous difficulties which are hardly realized by anybody except the anthropologist. In culture-contact areas it assumes even greater complexity. The Report of an Educational Conference of the Pacific region [1] points out how effectively it moulds 'native institutions, standards of living, moral codes and inherent values', and claims that it is more potent than even the direct attacks by the State and economic factors. The Conference frankly admits 'that when we institute a system of education we do not know precisely what we are doing'. It pointed out how the anthropologist can serve the educationist by placing at the latter's disposal the results of investigations

[1] *Education in Pacific Countries* by Felix M. Keesing, Professor of Anthropology, University of Hawaii, Oxford University Press, 1938.

into indigenous cultures especially his knowledge about the inter-relation of social, economic, legal, religious and political ties which are the main supports of the community. Investigators in Africa also sing at the same strain. Mr. H. S. Scott, in a discussion about East Africa, remarked that though anthropological knowledge has been utilized for administrative purposes to a certain extent, it has not been drawn upon for education of the primitive children in Africa. The result, according to him, is subversive of native interest. Major Hanns Vischer, Educational Adviser to the Colonial Office, drew attention to the necessity of inculcating a moral code as an element of native education. The introduction of Islamic or Christian moral codes in native educational system of Africa does not meet with his approval. Comparing the West African students in London with the graduates of Achimota, he remarks how the former suffer from lack of a code of values of their own which only can support a man when he is separated from his own environment. The graduates of Achimota, according to him, on the other hand, having been trained to regard native customs and traditions as worthy of respect, are not subjected to this limitation. Major Vischer urges the anthropologists to work out a morality based on present sociological realities which, he hopes, will fulfil a serious want in the native education of Africa and will substantially help to smooth the clash between modern morality, imported by natives brought up in European contact or trained in Christian schools, and tribal morality.

In the matter of tribal education India does not differ much from Africa. Rather, the problem is more complicated here. In our country, besides the activities of the Christian Missionaries we have to reckon with the institutions of the advanced Indians who also have been subjected to a system of education which can hardly be characterized as suitable to their manners of life, congenial to their traditions, or helpful in the solution of their national or individual economic problems. To-day I shall not deal with the educational problems of the advanced Indians though, I may assure you, the anthropologist has a definite part to play even in this sphere of our national activities but I shall confine my remarks to the tribal communities of India.

We have already remarked how the various tribal communities of India have come in contact with the advanced Indians and the Europeans. Attempts have been made to educate the primitive children both by the government of the country and by various philanthropic individuals and institutions the most important among the last being the Christian Missionaries. I reserve my remarks about Christian Missionary education for a later section.

Education is perhaps rightly claimed as the panacea of all evils that befall mankind. But people differ in its definition,

and naturally it has different types. There is one kind of education which uplifts the individual morally and intellectually and makes him fit for the struggle for existence. There is another kind of education which is intended for the exploitation of the so-called educated. There is a third type of education which the enthusiasts in their zeal for ameliorating the condition of the poor and the ill-fated impose upon them without considering their necessity or capacity. We have neither time nor inclination to discuss this point here but suffice it to say that much labour and more public money have been squandered and are still being squandered in imparting education which does neither suit the people nor help them to put a morsel of food into their mouth. On the other hand, it often creates a group of drones in the society who disdain labour of all kinds being proud of their so-called education and live as parasites. Where the imposition of a particular system of education is due to wilful commission, we have nothing to say but where it is not so, the anthropologist can, no doubt, help the educationist with his advice.

Speaking about the type of education worth imparting to American children the multi-millionaire motor-monarch Mr. Henry Ford, who turned an amateur school-teacher at the age of seventy-five after his retirement from business, remarks 'Education is not something to prepare you for life, but rather a part of life itself. Earning should go hand in hand with learning. These little children in school, earning money with their vegetable garden; teaching each other their own experiences; helping each other to plant and cultivate,—THEY are getting REAL education. For, true education consists in learning to do, by doing; learning to help, by helping; learning to earn, by earning.' This is from the pen of a man whom we may regard as a true representative of the materialistic West and who has risen from the masses and built up his fortune inch by inch by dint of his own labour. Now let us see what the spiritualistic East regards as the true type of education for modern India. '. . . . . as to primary education my confirmed opinion is that the commencement of training by teaching the alphabet and reading and writing hampers their intellectual growth. I would not teach them the alphabet till they have had an elementary knowledge of history, geography, mental arithmetic and the art (say) of spinning. Through these three I should develop their intelligence.' 'As to the necessity and value of regarding the teaching of village handicrafts as the pivot and centre of education I have no manner of doubt. The method adopted in the institutions of India I do not call education, i.e. drawing out the best in man, but a debauchery of the mind.' This is the opinion of Mahatma Gandhi. Now we may ask, is there any fundamental difference in the views of these two great men of the East and the West? We, however, do not

find any. We are to remember that this system of education is advocated for the children of the advanced people and if you visit the tribal areas you will realize how much more imperative it is for them. An example from one of our tribal zones will clearly bring out how blindly we are following the trodden path.

The Valley of Manipur surrounded on all sides by lofty hill ranges is a secluded spot where its inhabitants have developed a culture of their own under ancient and medieval Hindu influence. The land is very fertile and the people are mainly agriculturists. The Manipuri women are reputed for the textiles they weave on their simple looms. Thus, the people do not suffer from want of food or clothing. The few other industries and trade are subservient to these two basic occupations. Here, a few High English Schools have been established for the boys and one for the girls too and there is an attempt to establish a college. A net-work of primary schools exist throughout the State. I found two such institutions in two Kuki villages and there are many more in other villages inhabited by the hill tribes. The two schools I saw used to teach their students how to read and write Meithei besides a little arithmetic, which they managed to forget within a few months after their departure from the school. This I say from personal experience. We cannot understand how this type of education can benefit the Kuki boys. It does not help them to earn a single farthing nor does it teach them the means of improving their agricultural methods on which their life depends. It is rightly argued that primary education opens the vistas of knowledge to the illiterate, but not to those who forget whatever they learn within a few months of their leaving the school. This requires a tradition and other extramural facilities which the tribal society lacks. In a press communique issued by the Madras Government on 26th June, 1937, just before the Congress ministry took over the charge of government we meet with the following remarks: 'In the whole of India 74 per cent of those who attend primary schools fail to reach class IV where they may be said to attain permanent literacy. In Madras the wastage is as much as 69 per cent, in the United Provinces and the Punjab 75 per cent; Bombay 59 per cent and C.P. 52 per cent are better but Bihar and Orissa with 85 per cent and Bengal with 80 per cent wastage are the worst.' If this be the percentage of waste among people who include both advanced and tribal groups, you can easily imagine the condition among the latter group alone.

This system of educating the aboriginal is at best futile and results in useless expenditure of money. Further it is difficult to understand how high school education will help Manipuri agriculture or textile industry. The employments at the disposal of the State are very limited and the students who pass out of these schools every year will increase the number of the

unemployed as they no longer think of going back to their fields. During the first few years they will be idolized by the community but this will soon pass away when they will be looked upon as parasites and it is not impossible that they will be a source of trouble to the State. The education which was intended to produce a race of clerks for the East India Company has no justification for its introduction in a Native State like Manipur. Instead of copying what has been forced upon Bengal, Manipur could have evolved a type of education suitable for its subjects with a view to improve the two main occupations of the people, namely agriculture and textile industry.

In Manipur every girl has to learn weaving if she wants to get married. Every one tries to excel every other in this art. This was and this still is the ideal of Manipuri womanhood. But the establishment of a high school for the girls is sure to affect adversely this homely and useful ideal. In a few years more, I am afraid, the ideal wife will be one who knows how to read and write and not she who weaves well and an old useful industry will be sacrificed at the altar of so-called modern culture. Mrs. Sylvia Leith-Ross in her study of the Ibo Women of Nigeria refers to a similar effect brought about by English education spread by Christian Missionaries. Though a higher bride-price is claimed for girls with this type of education even to-day, yet already Ibo men have begun to prefer uneducated wives who are less expensive but more efficient. Men and women contribute equally to the solution of the bread-problem among the Ibos and the present system of education which merely trains the girls to play the part of fine young ladies lead them and their husbands to more and more uncomfortable situations. If you investigate the missionary attempts in the District of Ranchi in Chota Nagpur to educate the tribal people you will perhaps find the same condition.

Besides helping to find out the proper type of education to be imparted to a people anthropology may also assist in creating suitable teachers for such areas and this is equally important. Juvenile mind is attracted by sympathy and a successful teacher is one who can attract his students. We have already stated that sympathy is born of knowledge. When a teacher from a higher class or culture comes to a school where the students are recruited from a backward people he generally assumes a patronizing attitude and often looks down upon his pupils. Though this may not find any outward expression yet every student realizes it in a very short time almost instinctively and this makes them apathetic or even sometimes inimical towards the teacher. Love and respect of the students are the two most important assets of a teacher. His success depends on them. Moreover, if a teacher is not acquainted with the home-atmosphere of his students it is difficult for him to combat with the evils which originate there. Thus character and

knowledge are the two most important factors in the make-up of a good teacher and this is dependent to a great extent on Anthropology.

Anthropology and Social Service

In recent years a number of philanthropic or religious missions have sprung up in India among the children of the soil. But they cannot be compared with the Christian Missions of Europe and America either in magnitude, organization or influence. In spite of this, the Indian organizations are slowly gathering strength and they have a fair field and fruitful future. Though these Missions are now being worked by philanthropic people who have devoted their lives to the service of suffering humanity, yet this stage is sure to pass away and will be followed by a more organized one when specially trained people will be necessary to carry out the work. In Europe and America, missionary work has provided employment to a large number of students of anthropology and India also will provide the same in the near future.

Missionary work may be classified into different categories according to the main aim and ideal of the group. There are social missionaries, political missionaries and religious missionaries. But each one of them combines the functions of the other two to a certain degree and so each class is equally potent to bring about good or evil to the people among whom it works. They represent disruptive forces and the very nature of their work is responsible for this character. They introduce new ideas about social behaviour, political thoughts and religious beliefs and practices. The established order of the community is attacked at different points—points which are comparatively more vulnerable—and a breach at one region is the precursor to more at others, and at last the deluge comes. The less advanced the community the more exposed it is to the preachings of these missionaries. I do not, however, deny that many of these bodies have rendered ideal service to our less advanced brethren. They have brought medical relief to thousands of suffering humanity, they have introduced hundreds of thousands of our ignorant brethren into the mysterious temple of the goddess of learning and they have put food into the mouth of millions of starving population. It is all true but all these have not been given free; for every patient relieved, for every letter learned and for every morsel of food a price has to be paid. It is high time to examine both sides of the scale, to find out whether the price paid is commensurate with or exceeds the so-called gift. For this purpose we shall not subject to an examination the Indian missions which are more or less weak imitations of the Christian missionary organizations of Europe and America, but shall assess the value of Christian missionary

work and that not in India but in Africa because the Dark Continent perhaps shows the maximum activity of these Missionary organizations and there has been practically wholesale conversion in particular areas and tribes. There are, in Africa, tribes with authentic records about social, economic, political and religious systems of pre-Christian days and trained anthropologists have studied such groups in recent years with a special view to find out the effects of Christianization. Such a group is the Baganda of Uganda and Dr. L. P. Mair in assessing the effect of Christianization writes 'Christian missionaries have set their faces against all the patently "uncivilized" aspects of native culture, whether or not they were directly forbidden by the Scriptures: they have opposed polygamy, slavery, the payment of bride-price, initiation ceremonies, dancing, wailing at funerals, and the belief in magic, along with human sacrifice and the exposure of twins .... yet, to the anthropologist who sees culture as an organic whole, even those institutions which seem in terms of human suffering most cruel will be found to have some place in the maintenance of the society, such that their uncomprehending destruction must carry with it the loss of essential elements in the social structure; while the condemnation of others will prove often to be due to mere failure to recognize their positive value.'[1] According to the same author there are factors of great importance for the individual for which control is provided by magic. Christianity does not supply any substitute for it. Cure of disease, faithfulness of a wife, capacity to pay off debts and success in business are a few of these factors for which Christianity has failed to replace magic. In the same society Christianity has destroyed beliefs about automatic supernatural punishments especially those relating to unchastity. The result is laxity in sexual morality and Christianity has not been able to set up the moral standard of European society in this African community. In conclusion Dr. Mair writes 'Regarded strictly in its religious aspect, as a system of beliefs and practices to which man turns for reassurance in facing the unknown and confirmation of his moral standards, it is very difficult to judge how far Christianity has really been assimilated into Baganda culture.'[2]

In another area, Malaita, in the Solomons, Christianity is firmly rooted probably owing to certain similarity with the heathen past. Still it has caused disintegration in several aspects of native social life. Christian schools are responsible for the impudence and laziness of the students. The children no longer respect their parents and help them in their leisure hours but merely play and roam about for long hours after the lessons are finished. Attempts to stop it have proved futile. Dr. H. I.

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[1] L. P. Mair—An African People in the Twentieth Century, p. 3.
[2] L. P. Mair—*ibid.*, p. 261.

Hogbin who studied these islanders informs that young people in mission areas develop interest in sexual matters at an earlier age.[1] He records a number of cases of sexual unchastity among young folk leading to premarital pregnancy. 'Nowadays when an intrigue is discovered the teachers and parents usually insist on marriage of the couple'. But older people are horrified and chafe at being prevented from killing the delinquents.

We are ready to believe that the missionaries begin their work with the best of intentions but good will is not sufficient safeguard against unconscious or ill-judged measures. When you once let loose the forces of disruption there is no means of knowing how far they will go and when they will cease. Thus bride-price as an institution has received attention from the missionaries in the Solomon Islands. It has been prohibited as an evil custom among the converts. Dr. Hogbin writes 'I have myself heard a missionary deplore the fact that the natives have such little regard for their women as to buy and sell them like pigs. He was under the impression that the transfer of valuables gives the husband the right to treat his wife just as he pleases.' This is far from the truth. The parents of the girl who receive the bride-price do not hoard it for their personal use but distribute it among relatives 'so that if wealth flows out of the kinship group when the men marry it flows back again with the wedding of the girls'. But out of this transaction society in the Solomon is endowed with an important social control. Belief in magic and ancestor cult, and payment for brides are the most effective sources of the authority of the elders over the youth. The Church in this particular area realized it too late and a compromise was effected in 1929, when bride-price was allowed but fixed at three *tafuli'ae* (approximately worth two pigs). But this has not solved the problem as the amount is too low and can be earned by any normal youngman who will not have to depend on his relations for this. Thus the new measure does not establish the institution at its original position.[2] Dependence of the youth on the aged is a strong link in the social management of Malaita and it cannot be destroyed without disturbing the other social traits which are linked with it. Polygyny is another institution which has met with the disapproval of the Church in some Melanesian Islands. The missionaries have even induced the Administration to prohibit it in particular areas. In the Trobriand islands[3] the prohibition of polygyny undermined the position of the chiefs by robbing them of the most important source of income and led to subversion of native authority and caused general disorder. This shows how even a perfectly

1 H. I. Hogbin—Experiments in Civilization, p. 204.
2 H. I. Hogbin—*ibid.*, pp. 212 and 213.
3 Malinowski—Sexual Life of Savages, pp. 110 and 114.

desirable and beneficial measure from our standpoint may be injurious to a community with a different social system. These are only a few instances of such maladjustments brought about by missionary attempts. So far as regards well-intentioned attempts without a knowledge of the situation.

The motive which guides the Christian missionary as well as the realm of his duty and obligation are beyond the jurisdiction of scientific criticism but not so his methods. The missionaries have accumulated much anthropological knowledge but they have used it less. A distinguished missionary-anthropologist speaking of missionary methods writes that the 'missionaries have regarded themselves as agents of European civilization and have thought it part of their duty to spread the use of English language, English clothing, English music—the whole gamut of our culture. They have confounded Christianity with western civilization. In my opinion this is a mistaken view of the Christian mission. It is not his business to substitute European tribal customs for African or Polynesian.'[1] But unfortunately they have made this attempt in most of the places where they have been commissioned to carry the message of Christ. Charles Jhonson a distinguished missionary of Zululand—not an anthropologist—declared in unequivocal language how this method had been carried to the farthest extreme. He wrote 'the missionaries were the products of their time. The European consciousness of superiority to the Bantu was a very marked feature of that period . . . . No one tried, as far as can be judged, to learn what there was of good in the Bantu system of life and conduct, and to sublimate it by infusing Christian doctrine and ethics into it. The central idea was to prise individuals off the mass of the national life, rather than to leaven the whole nation with Christian teaching. When so prised off the individuals were gathered into missionary reserves and no longer permitted to take part in the life of their nation.' It is of course claimed that this criticism of a past age does not hold good for the present, nor for all regions. Unfortunately it is still applicable to India and this has been evidenced by no less a person than a provincial director of ethnography—himself a Christian Englishman and a high government official.

We are not in a position, at present to assess Christian missionary work among tribal people of India, as neither the Government nor the public have made any serious attempt to subject this kind of work to a systematic study by trained people. But the attempts of the Christian Missions among Harijan people have received some attention from political leaders and reports of their work have come out in the press. These, after

[1] *J.R.A.I.*, Vol. LXIV, 1934—Presidential Address by Rev. E. W. Smith.

all, do not show them in a good light. It appears that the Christian Missions in their zeal for conversion have lost sight of their ultimate aim. They have misconstrued the means for the end. Instead of making it their life's work to carry the message of universal and eternal love to the suffering humanity which the Son of God was commissioned to bring to this world they merely spend all their energy in inducing people to go through the ritual of baptism. Such conversions are not the effect of a real change of mind brought about by true Christian teachings which claim to enlighten the soul and to satisfy its craving for eternal love and knowledge. On the other hand, they are occasioned by worldly inducements of momentary importance. The result is that the converts often flock back to their old fold as soon as the temporary need is removed. The very nature of these *en masse* conversions proves the truth of the above assertion and indicates the state of mind which induces such conversions. I shall give only two instances of this conversion for conversion's sake.

In 1936 a Roman Catholic Mission came to Arrah and began work. At first they tried to bring to their denomination the Protestant converts of the locality and were successful to a certain extent. But later they turned their attention to the Hindu Harijans. Their method is to visit a village and make themselves familiar with its inhabitants. Next they establish a school with a Harijan teacher who is either himself an influential man of the locality or has an influential relation there. Thus they bide their time until a tension ensues between the Harijans and the other inhabitants of the village or a litigation starts between the two groups. Then they side with the Harijans, give them money and advice. 'They are thus hailed as saviours and conversion follows as if to repay the obligation.' In thana Piro they converted about 450 persons within a period of a little over one year. 'The one remarkable feature of these recent conversions is that they take place *en masse*. Whenever a village Harijan leader accepts the new faith almost all belonging to his clan follow him. Sometimes an influential Sardar is instrumental in converting people of his community living in several villages.' Such conversions were not due to convictions but to socio-economic reasons which were not far to seek. Success was due to the peculiar situation in which social disabilities and economic iniquities had disturbed the mental equilibrium of this oppressed social group.[1]

Here is another instance of such conversion. In Salem District during 1939 Harijans were being converted by the Christian Missions on a mass scale. The caste Hindus decided not to employ these converts during religious festivals or social ceremonies such as birth, marriage and death, or even in

[1] M. K. Gandhi—'How they convert', *Harijan*, June 19, 1937.

agricultural works. This meant a substantial loss of income both in cash and kind to these converts. The result was that many of them sought reconversion and came back to their former fold. 'This is due no more to a change in belief than their first conversion was. Prospects of material gain lured them to Christianity; actual loss of employment compels them to come back. Thus during 1939 as many as 153 people from three villages have been reconverted here, while many were reconverted in other places ....' [1] These two instances clearly indicate the aims and methods of at least some, if not all, of the Christian Missions working in India. Another significant fact about Christian missionary work in India is its utter failure among the middle and the upper classes. This shows its weakness. It is not conviction which attracts people to Christianity but lure of worldly gain. Africa also testifies to this fact and anthropologists working in different parts of that continent have repeatedly attracted our attention to this feature of Christian conversion.

Christianity has been adopted by subject races when it has been presented to them by members of the governing nation, not because of its inherent merits but because of its material advantages. The white man's wealth and his mechanical mastery over natural forces produce a sense of inferiority and dazzle eyes when first viewed. When they realize that the way to this wealth is through the school they assemble at its door and begin to devour without discrimination whatever is placed before them. 'In the light of new knowledge the old traditional life is easily despised. The ancient language appears barbarous .... Old customs, old loyalties are thrown overboard.' To what an extent this systematic denationalization runs can be gathered from the fact that in certain parts of Africa 'not a single African leader considered it possible for anybody to be at once a Christian and an African'. If this be the real position, it is now time to stand and reckon whether this vast amount of wealth in men and money can be employed in a better and more profitable manner.

Fortunately, we hear, there is a change in the attitude of the missionaries at least in other countries. They have realized the existence of valuable traits in native culture and are now trying to make a synthesis of European and local cultures through the schools and missions. This new attitude demands closer co-operation with anthropology. Sublimation of local traits needs careful research into the nature of local institutions and beliefs whose essence is proposed to be conserved in the new synthesis. This, no doubt, pushes the missionaries into the embrace of the anthropologists for help in discovering the vital elements of culture. Already the Protestant missionary societies

[1] M. K. Gandhi—*Harijan*, January, 27, 1940.

have established their own Department of Social and Industrial Research. The International Institute of African Languages and Cultures owes its origin to a group of missionaries and their friends. Missionaries on furlough now attend lectures on anthropology and already there are in the field a number of academically trained anthropologists in the service of the different Missions. Dr. Hogbin of Sydney University wrote in 1939 that 'the Department of Anthropology in the University of Sydney during the last few years has trained over seventy candidates for the mission field in New Guinea, Papua, Fiji and Australia.' [1]

I wish to attract here the attention of our Indian missionary organizations especially those which are engaged in work among primitive tribes. They are to take lessons from their compeers of the other faith. They also may fall into the same traps which have proved ruinous to their Christian brethren. No doubt they are nearer to their subjects in colour, faith and social values. There is of course no abrupt break between the primitive and the advanced in India: one gradually merges into the other through the intermediate grades of the so-called exterior castes. This is to their advantage as it helps them to realize the mental make-up of the primitive more easily. But this should not lull them to security. There are innumerable pitfalls and they must be armed with knowledge to avoid them. We have already stated that most of the Indian organizations are worked by men who have shouldered the task out of sheer love and sympathy for the suffering humanity. They have not been attracted by any hope of emoluments. But this condition cannot and will not last for ever. A time will come when paid workers have to be employed for this type of work. But as it stands at present we have the unique opportunity to utilize this army of self-sacrificing spirits for the purpose of social service throughout the country. The material is no doubt good but it requires proper moulding and this can be accomplished if our Universities take up the task. Training is necessary for every kind of work and social service is no exception. The Universities by opening Social Service Classes under suitable teachers and by providing for instruction in a number of subjects such as rural hygiene, rural sanitation, adult education, co-operation, village industries, etc., with anthropology at their forefront, may give a new orientation to this branch of our national activities.

Anthropology and Administration

The importance of anthropological knowledge in administrative affairs is recognized nowadays by different countries especially by those with a section of tribal population. In India, according to the last Census operations, we have a tribal

[1] Dr. H. I. Hogbin—Experiments in Civilization, p. 249.

population of more than 22 millions out of a total population of a little over 352 millions or in other words out of every 16 persons one is an aboriginal. These people occupy the most inhospitable regions of our country. Their habitat extends over deep forests and steep hill ranges where they eke out a miserable existence. Away from the ken of civilized men and unaware of them these children of nature silently fight with inhospitable environment and wrest from it the barest minimum necessary for keeping body and soul together. They have no idea that the State has any responsibility towards them or that their poverty is in any way connected with the activities of their more prosperous neighbours. They attribute their ill fortunes to the machinations of evil spirits and remain satisfied with making offerings to them. But their ignorance is no excuse for us. The Government of the country as well as the educated public have no justification for shutting their eyes from the miseries of these simple people. We have both legal and moral responsibility for these 22 millions of wretched souls. In India, the aboriginal tribes have to face two sets of exploiters: there are the foreigners to whom every Indian, whether savage or civilized, is equally exposed, and besides them there are the advanced Indians, who have established themselves in various capacities in the midst of the aboriginal population and are advancing their own interest at the expense of the savage. The Indian aborigines thus require double protection—protection from both internal and external exploiters. This has been acknowledged, in theory at least, by the British Parliament. The Government of India Act, 1935, provides (in Sections 91 and 92) for declaring these tribal tracts as 'excluded or partially excluded areas' and they have been placed under the direct charge of the Provincial Governors. Such areas are free from the jurisdiction of the ordinary administrative machinery as well as the Provincial and the Central legislatures. This means a different administrative system intended to provide protection to the aborigines from the representatives of the internal exploiters. But it has not saved them from the foreign exploiters. Moreover, the type of administration set up for these areas does not differ much, in essence at least, from what was in existence in the past or what we find outside these areas at present. These are half-hearted measures which look well in administrative reports but do not help much in actual life. The inadequacy of these measures will appear from a comparison with the steps taken in other parts of the world as for example in Africa, to improve the condition of the tribal people.

In Africa the European nations have come in intimate contact with the tribal people and an experiment of great magnitude and of immense human interest is going on there in the matter of administering the aboriginal population. A

brief reference to this may give us some idea of what possibly can be done in India in the same sphere with necessary alterations. 'The central problem which faces Government in East and Central Africa is to discover a basis on which white and black, with Asiatics as well, can live together under conditions of rapid economic change and with adequate opportunities for political development.' The policy of Parallel Institutions provides according to a large number of thinkers the best solution of the problem. This policy is often known as Indirect or Dependent Rule. It has been long perceived in Africa that under Direct Rule, the tribal organizations with their customary laws and traditions either gradually disintegrate or are forced underground where they tend to take the form of anti-governmental organizations and secret societies. This led to a change from Direct to Indirect Rule which was initiated from the beginning of this century. As a result, the greater part of tribal Africa is now being administered on this principle. What are the essential points of this Indirect Rule? In the language of Miss Margery Perham 'it is a system by which the tutelary power recognizes existing African societies and assists them to adapt themselves to the functions of local government.' It aims at developing local institutions under advanced guidance. It does not intend to keep them in a static condition but wants to develop them within the framework of native society so that they may conform to civilized standards. Now, this policy of Indirect Rule cannot be applied to administrative activities alone. If it is to be successful it must be applied simultaneously to other spheres as well such as social organization, education, religion and economic affairs.

What is the relation between this new policy and anthropology? In one word it may be characterized as an experiment in applied anthropology. Though it will be too much to claim that the policy of Indirect Rule in Africa originated from anthropological knowledge, it is clear that its extension has been preceded by wide anthropological research on which it was certainly based. To take an instance, in Northern Nigeria officers were required to come in close contact with the natives and collect materials on their life while preparing the tax-roll. Rev. E. W. Smith, once President of the Royal Anthropological Institute, referring to this custom writes—'The material thus collected formed the basis of the policy of government which sought to work with and for, and not against, the natural and national evolution of the peoples. So it was found possible to extend Indirect Rule to pagan communities whom few at one time would have expected to be susceptible to this mode of government. In later years efforts have been directed to establishing the same system in the southern provinces of Nigeria after painstaking investigations into the indigenous forms of clan or tribal control. In the Anglo-Egyptian Sudan, Gold Coast, Northern Rhodesia

and Nyasaland it has also, in varying degrees of completeness been instituted.' After the Great War this system was introduced into the mandated territories under Britain where a consistent and patient attempt was made to resuscitate the indigenous mode of government. This is the story of Cameroons, Togoland, and Tanganyika Territory.

How far and in what manner anthropological knowledge can be applied to problems of tribal administration has been experimented upon among the Hehe tribe of Iringa District in Tanganyika Territory for a period of one year. The District Officer Mr. Bruce Hutt referred his administrative problems to Mr. G. Gordon Brown the anthropologist who had been conducting anthropological field-work among the tribe for some time past. They followed the principle laid down by Prof. Malinowski that 'the practical man should be asked to state his needs as regards knowledge on savage law, economics, customs and institutions: he would then stimulate the scientific anthropologist to a most fruitful line of research, and thus receive information without which he often gropes in the dark'. They decided to collaborate on the basis that the administrator will make practical decisions on the information supplied by the anthropologist on whom he will fully rely as to the accuracy of the information. The latter also, on his part, would not question the decision of the administrator in case of a difference of opinion provided all the informations have been laid before him. The result of this experiment was published in the form of a book called *Anthropology in Action: An experiment in the Iringa District of the Iringa Province, Tanganyika Territory* in 1935 and shows how successfully anthropological knowledge can be applied for administrative purposes.

The works of the Fellows of the International Institute of African Languages and Cultures have proved beyond doubt the value of anthropological knowledge in practical administration. The Report presented to the Rockefeller Foundation on the work of this Institute (July 1, 1931—June 30, 1939) claims that 'The Governments, indeed, of some of the territories in which the Fellows have worked have shown themselves anxious to obtain their further services'; that Dr. Margaret Read has begun 'a study of the effects of the emigration of adult males on village life' in Nyasaland at the request of the Government; and that Dr. S. F. Nadel has been appointed Government Anthropologist in Anglo-Egyptian Sudan and is at present working in the Nuba Province. The Government of Northern Rhodesia 'set up in 1937 the first institute for systematic sociological research in colonial Africa', though its formal inauguration has been deferred till 1940. This is the Rhodes-Livingstone Institute with its headquarters at Livingstone. The government supplies 52 per cent of its funds while the rest is derived from munificent donations from commercial and industrial

organizations. Already two anthropologists are working under this Institute in Northern Rhodesia and more will be appointed with the increase in funds. The same Report states 'The Fellows have been asked for advice on special subjects by the Governments of the territories in which they were at work. To give some examples, Dr. M. Fortes was asked by the Government of the Gold Coast for a report on marriage law among the Tallensi, and he also prepared a plan for the new constitution for the Tale Native Administration, which became the basis for the constitution introduced in 1936. In Nigeria Dr. Nadel was consulted on a number of subjects.' He advised the government about the 'traditional system of village political organization among the Nupe and the possibility of using it for purposes of modern administration. He also dealt with questions relating to the adoption of special pagan courts in addition to the existing Muhammadan courts of the Emirate, the reorganization of the town administration of Bida, the earning power and income of the inhabitants of Bida in connection with a reassessment of taxation which was contemplated, and questions of agricultural technique as they affected a Government scheme for introducing mixed farming. Dr. Wagner was asked by the Government of Kenya for advice and information on problems of Kavirondo land tenure ....'

The same intimacy between anthropology and administration has been demonstrated from another quarter. The work of Dr. Raymond Firth in Tikopia, a small island in the Pacific with a population of twelve hundred souls, shows how the 'traditional equilibrium between population and food supply was maintained, among other things, by "a celibacy in which chastity was not enforced", by "a discreet infanticide", and by war'. Now this equilibrium has been upset by the Christian missionaries and the government. The former by discouraging premarital sexual intercourse has introduced earlier marriage leading to a greater number of progeny and the government have prohibited infanticide and war. Dr. Firth predicts overpopulation and famine at the end of another generation, if not earlier, if this rate of increase continues. Thus the Government is forewarned one generation ahead and it is the duty of the State to be forearmed. Dr. Firth points out in the same connection what alternative measures might be adopted such as agricultural development, migration, encouragement of birth-control, showing at the same time the inherent difficulties in each case. Thus the anthropologist has amply justified his claims about the value of technical information for governmental purposes.

We in India are also faced with the administration of a huge tribal population and with the advent of popular government, it is high time to move in the matter and see what improvement is possible in India. For this, at the first instance, a

thorough anthropological survey by specialists is necessary. This is to be followed by employment of officers with anthropological training who will keep themselves abreast with the changes in the cultural make-up of the people over whom they are placed and thereby keep the records of the specialists up-to-date. This is equally necessary for tribal and non-tribal areas. As a rule all officers of the State to be employed in the tribal areas should have either previous anthropological training or arrangements should be made to give such training after appointment in or transfer to such tracts. This rule is to be observed not only in connection with executive and judicial officers but also with those who belong to the police department and forest service. In fact, the Government is required to create a band of officers specially fitted for this type of work by education and inherent sympathy. They should not allow things to drift. The force of this argument may be brought home by reference to the many cases of bungling caused by lack of anthropological knowledge of the officers employed in tribal areas but owing to lack of time I desist from them at present. It is not, however, my intention to cast any aspersion on the ability and sagacity of the officers concerned at present with the administration of tribal people but there is surely sufficient scope for improvement in this particular sphere of activity. If the different Provincial Governments can be persuaded to adopt this policy, it will, diminish the chances of maladministration. This has been done in the case of Africa where it has proved successful and there is every chance of this policy becoming successful in India too.

CONCLUSION

So long our picture included mainly the primitive or the backward peoples. But anthropology is not concerned with them alone. The Functional School of Anthropology has demonstrated without leaving any scope for doubt, that it can be applied with equal force in solving the problems of civilized life. Anthropology is no longer concerned with the savage only: it has passed that stage.

India is at present passing through a transitional period not only in politics but also in its social, religious and economic affairs. We are confronted with queries at every turn. The politician, the social reformer, the economist and the religious enthusiast—every one of them is required to solve new problems. At this critical stage of our national life a minute analysis of our culture based on facts collected from all possible sources would be of immense help to the former. They will know what we have and this will help and guide them to formulate new ideas and ideals and new paths in their respective spheres. Now, this analysis of culture can only be undertaken by trained anthropologists, who are best equipped to do it. This further

broadens our field of activity. Problems like female emancipation, dismemberment of the joint family, dying out of the artisan castes and decay of the middle class—to mention a few only—are causing anxiety to the best minds of India. Each and every one of them is a vital question affecting the whole social organism and they should not be left to amatours and enthusiasts for solution but should be tackled by properly trained scientific men. Here we have the glimpse of a wider horizon of activity for the anthropologist who may thus serve the State and his society, and prove himself to be an indispensable adjunct to modern life. This is to my mind the highest realization of the Science of Man.

SECTION OF MEDICAL AND VETERINARY RESEARCH

President:—A. C. Ukil, M.B., M.S.P.E., F.S.M.F.B., F.N.I.

Presidential Address

(*Delivered on Jan. 3, 1941*)

SOME ASPECTS OF PUBLIC HEALTH IN INDIA

'Man hardly realizes that he can shape his own destiny'—
Bergson.

A HISTORICAL PERSPECTIVE

From the earliest times man has been actuated by the instinct of self-preservation and the natural impulse of life-interest and life-protection which has been expressed in various ways, such as the raising of food by agriculture and its storage, shelter, water-supply, land drainage, irrigation and removal of refuse. The occurrence of disease in individuals led them to evolve certain empirical rules of personal hygiene and the urge for herding together induced them to evolve and utilize health services according to their concept. For example, the recent excavations at Mahenjo Daro and Harappa in the Indus Valley and the Punjab have shown that, as far back as 3500 B.C. or even earlier (pre-Aryan civilization), the people of those days had an astonishingly high level of sanitation. Not only were there bath-rooms in the private houses with water-proofed brick floors and house latrines but a system of drainage with socketed drain pipes was provided by which the sewage was carried into street tanks and thence removed by scavengers. Sir John Marshall notes that every street, alley-way and passage had its own covered conduits of finely-chiselled brick laid with great precision and that the whole drainage system was extremely well developed. It has to be remembered that the Bronze Age peoples of England at this time were living in small grass or mud-covered huts. Civilization in Europe in the sense that we know it was a much later affair than in these parts of India and Egypt.

Then came the Vedic period of Hindu medicine (about 1500 B.C.), which attained its highest development between 600 B.C. and 200 A.D. The available literature shows that considerable progress was achieved in anatomy, major and minor surgery, internal medicine and pathology, midwifery and children's diseases, hygiene and toxicology, and elixir (internal

secretions) and sexual hygiene. Hospital services, both for men and animals, existed and nursing services were utilized. There were excellent rules of personal hygiene and some of community hygiene. Castellani has noted that at Anuradhapura in Ceylon a sanitary officer was stationed to look after the health of ten villages. But the palmy days of this civilization gradually receded, and although attempts were made to conserve the knowledge which already existed the eastern savants gradually became speculative and bound by traditions. The period between the 2nd to the 15th century was a very dark period for the science of medicine, more particularly in Europe.

The contributions of Hippocrates, Alexandrian School of thought and Galen led to the foundation of Greeko-Roman Medicine in Europe. Gradually since the middle of the 15th century, the work of Vesalius, Paracelsus, Fracastoro, Malpighi, Harvey, Leewenhoek, Sydenham, Ramazzini and others laid the foundations of modern medicine. Meantime plague and pestilences repeatedly overran Europe owing to the lack of knowledge regarding the nature of disease, its causation and propagation.

The Scientific Renaissance in the 18th century in other fields, viz. chemistry, geology, botany, zoology, physics, mathematics and astronomy, made a deep impression on the learned world. In the field of public health, workers were just beginning to wake up and the medical history of the century was crowned in 1798 by the discovery of vaccination by Edward Jenner. Besides the development of the scientific spirit, an extraordinary reaction to the new conditions of life was noticeable in this period, viz. the growth of a new motive of humanitarianism urging the inner man to ameliorate the condition of the stricken and the less favourably placed people in society. No doubt this was fostered by the liberalism of the French Revolution and the writings of Voltaire, Bentham, Howard, Adam Smith and others. Private philanthropy came forward and made it possible for the establishment of numerous hospitals.

The application of steam power to factory uses in 1785 in England brought about the Industrial Revolution, which led to a radical transformation of social and economic life in Western Europe. The demand for labour gave rise to congestion and overcrowding, particularly in industrial areas. Inertia of sanitary authorities, vested interests, ignorance and public apathy accounted for appalling conditions of sanitary neglect. The sanitary condition of London in 1842 and that of New York in 1865 and the sanitary consciousness of their inhabitants can very well be compared with those of many Indian towns of to-day.

The beginning of the 19th century was marked by the dawning of social consciousness in Western Europe. England, because of its pioneer industrial developments, serves as a prototype to illustrate the social evolution paralleled in other

countries as they became industrialized. Widespread insanitation, repeated invasions by smallpox, cholera and plague, the gradual worsening of the working conditions of factory labour following rapid industrialization and the abounding miseries of the poor, social discontentment and a universal desire for amelioration led to the efforts of Chadwick and Simon to enquire into, report and press for public health reforms. Although the beginnings of environmental sanitation had already taken place, there was not a single comprehensive Act of Parliament concerned with the health of the people until 1845.

The Reform Act of 1832 gave franchise to one million citizens and the passing of the first Public Health Act of 1848 coincided with the maturation of social consciousness. Organized sanitation started with efforts to improve poor relief, public vaccination, drainage, water-supplies, burial reform, registration of births and deaths, and sanitary legislation.

The evolution of the experimental method rescued medicine from the clutches of magic, religion, guess work and quackery. The outstanding discoveries of the 19th century regarding anaesthesia, antiseptic surgery, the causation of infective diseases and the principles of immunology, along with the advances in chemistry, physics, physiology, pathology and pharmacology swept through Western Europe like a whirlwind and led to an increase in the knowledge of the diagnosis, prophylaxis and treatment of diseases. These fundamental advances established Hygiene and Preventive Medicine on a firmer basis and made it practicable, although there has always been a lag between scientific discoveries and their application. In the sphere of education, the advent of public education in 1870 became one of the great public services. The need for the abolition of quackery and the realization of the idea that an effective public health reform needed an enlightened and organized medical profession led to the passing of the Medical Act of 1858 and the establishment of the General Medical Council to regulate medical education and to control the publication of the State Pharmacopoeia. The advent of an organized medical profession, the public medical services and of post-graduate medical education also took place during this period. The Royal Sanitary Commission of 1869 laid down, under eleven heads, the national sanitary minimum of 'what is necessary for civilized social life in every locality' laying emphasis chiefly on the environmental services. Further political and economic progress facilitated the way to sanitary reform and social welfare. The demand for hospital isolation, extension of hospital accommodation, the reduction of poverty, the increase and control of food supply, the prevention of industrial diseases, the improvement of housing and working conditions in the factory, the education of defective children and the care of the insane were pressed forward.

After the industrial revolution and before the discoveries of microbiology, bad hygienic conditions in the environmental sphere were attended to more by architects, engineers and chemists than by physicians. As a result, insanitary dwellings were demolished and replaced by better ones, wide roads and parks were designed, water pipes and sewers laid, abattoirs were built, schools and public baths were constructed and measures taken against the adulteration of food. The beneficent result of these environmental services is reflected in the percentage reduction of mortality from tuberculosis in England from 100 to 70 by the time the tubercle bacillus was discovered (1882). Since the discoveries of the bacterial causation of infective diseases and the increasing knowledge of the principle of natural and artificial immunity against these diseases, the shotgun empirical methods of preventing infection of earlier days were replaced by precise methods of controlling infection conveyed through water-supplies, insect bites and direct contact. These researches were continued through the succeeding years of the 20th century leading to a fuller knowledge of the physiology of man's body in relation to his environment, further advance in the control of infective, tropical and parasitic diseases, remedial measures against nutritional disorders and disturbances of internal secretion and the development of chemotherapy against microbial diseases.

The establishment of the Medical Research Committee in 1913 and the impetus given to it during the last Great War led to the formation of the Medical Research Council in 1920 and of institutes for the study of local and tropical diseases, thus making it possible for the extension of medical research on various national health problems and its application by the individual, the community and the State.

These scientific advances enabled a fuller apprehension of positive health, heralded the emergence of sociological medicine and profoundly affected the action and purpose of statecraft. Political and economic advance was followed by legislation and state action on the improvement of working conditions and occupational hygiene, school health including the provision of school meals and preventive treatment of defects, the prevention of maternal and infant mortality, health, unemployment and invalidity insurance, immunization against disease, the provision of better and safer food, and the prevention and care of mental deficiency, tuberculosis, venereal diseases and cancer. Subsidized housing and town-planning schemes made it possible for the eradication of slums, the construction of sanitary dwellings, the provision of cheap-rental houses and the abatement of overcrowding, resulting in a great improvement in sanitation and cleanliness. The advent of social emancipation since 1919 speeded up the reforms in every sphere. Finally, the creation of the Ministry of Reconstruction resulting in the formation of

the Ministry of Health, linked the central government to the corporations, councils, counties and districts and ensured a better co-ordination in the application of the principles of social welfare between the different departments or agencies. The difference between preventive and curative medicine was fast vanishing.

The requirements of the new situation needed a variety of institutions and a large category of personnel to look after them—doctors, technicians, specialists, nurses (public health, school health and institutional), chemists and auxiliaries (masseurs, radiologists, dispensing opticians, etc.)—by bringing clinical and non-clinical subjects closer to each other. Medical education had, therefore, to be reorganized and by 1936, 27 medical schools were engaged in turning out general practitioners, besides several institutions for post-graduate teaching. The present number (1939) of medical practitioners in England and Wales is 62,000 (or one doctor to 800 people), of whom 16,800 are panel practitioners looking after 17 millions insured at a cost of £8 millions. There are 1,400 Medical Officers of Health under the local authorities, 5,000 connected with the Poor Law Service, 500 tuberculosis officers, 110 venereal officers, 3,000 attached to maternity and child welfare centres, 2,000 on the Post Office list, 1,700 examining factory surgeons, 1,400 employed in the school medical service and 16,800 insurance practitioners. Over 2,700 hospitals with nearly 300,000 beds, including 10,000 maternity beds, are looking after curative medicine in a population of 50 millions. Every school week in the year the children from 100,000 homes are medically or dentally examined.

The cost of treatment and maintenance of sick persons amounts of £185 millions a year. The public expenditure on the preventive services or prevention of ill-health is £13 millions a year, while the public environmental services which largely contribute to good health cost £100 million a year. There has been a general desire for bringing the advantages of medical knowledge adequately within the reach of people, but the increasing complexity of modern health organization and the increased cost of treatment still render it difficult for many citizens to pay for the full range of services. This accounts for the delay in the treatment of disease. It is estimated that the economic loss caused by ill-health in England to-day still amounts to £300 million a year. Preventive health and social services and medical attention are still considered to be grossly insufficient.

The increasing significance of the social services is indicated by their expenditure. The total expenditure and the expenditure per capita had risen in Great Britain from £5 millions or 5*s.* per head in 1850 to £31 millions or 19*s.* per head in 1900 and to £400 millions or £8–17*s.* per head in 1934. The expenditure on Medical Services, exclusive of Mental, rose from £1½ million in 1900 to £17½ millions in 1934. Although acute diseases have been

largely controlled, many chronic ailments still baffle scientific workers and administrators.

In 1838, the crude death rate in England was 22 per thousand of population, in 1937 it was 12 per thousand. In 1838, the expectation of life at birth was 40 years for an English boy and 42 years for an English girl; in 1932, it stood at 58 years for a boy and 62 years for a girl; in other words, in 94 years the probability of life had risen by 18 years for a boy and 20 years for a girl. The spectacular decline in the incidence of some diseases, consequent on the application of available knowledge and co-incident social evolution is illustrated in some of the curves given below. The position of India in this regard is also indicated therein and by figures.

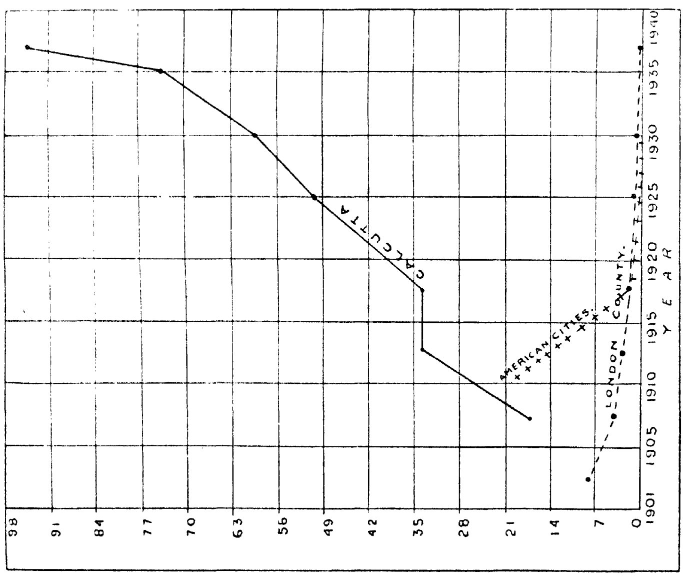
Modern Public Health—a field of social activity

Prof. Winslow of the Yale School of Medicine (1920) defines Public Health as 'the science and the art of preventing disease, prolonging life, and the promoting physical health and efficiency through organized community efforts for the sanitation of the environment, the control of community infections, the education of the individual in principles of personal hygiene, the organization of nursing services for the early diagnosis and preventive treatment of disease, and the development of the social machinery which will ensure to every individual in the community a standard of living adequate for the maintenance of health'. Social conditions react on health and health reacts on social conditions.

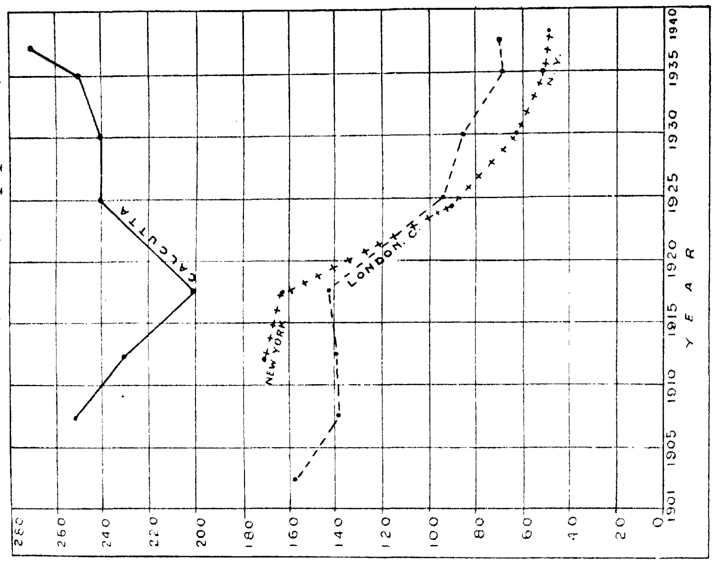
Bernal (Bernal, J. D.—The Social Functions of Science, 1939) goes so far as to say that 'it is probable that an overwhelming majority of diseases that occur throughout the world are due directly or indirectly to the lack of primary necessities, generally food, and many of the remainder are attributable to bad working conditions'. Considerations of health can seldom be divorced from economic, demographic and social factors. The human factor is the more important than other factors in raising the resisting power to diseases of backward countries like India. Speaking on nutrition, Sir John Orr expressed the following opinion in his Chadwick Lecture in 1935—'It may be assumed that any Government would accept as the first essential the necessity for ensuring that every individual in the State shall be able to get a diet sufficient to maintain health. If a system of production and marketing of foodstuffs fails to do this, the State, through its medical and social services, must pay for the treatment of those suffering from an inadequate diet'.

Medicine needs to recognize the whole nature of man, as shaped by his home, his surroundings, his education, his work, his economic status, his recreation and his struggles and aspirations. Medicine has thus become fundamentally a social science and a field of social activity in which is applied practically every

Typhoid and paratyphoid mortality in Calcutta, London and American cities (average for 78 cities)—1901 to 1937.
(Per 100,000 population.)



Respiratory tuberculosis mortality in (1901–1937) Calcutta, London and New York. (Per 100,000 population.)



Mortality figures for chief diseases in British India.

Diseases.	1900		1910		1920		1930		1937	
	Number of deaths.	Rate per 100,000.	Number of deaths.	Rate per 100,000.	Number of deaths.	Rate per 100,000.	Number of deaths.	Rate per 100,000.	Number of deaths.	Rate per 100,000.
Cholera ..	797,222	370	430,451	190	130,140	55	337,332	140	99,054	40
Plague ..	92,807	42·4	413,335	183	99,368	42	24,841	10	28,169	10
Small-pox ..	91,855	42	51,315	23	101,329	43	72,813	30	54,810	20
Fevers .. (Malaria, enteric, Kala-azar, and others.)	4,919,591	2,232	4,341,392	1,917	4,931,202	2,068	3,787,694	1,569	3,569,590	1,310
Dysentery and diarrhoea ..	530,654	241	267,672	118	218,734	92	237,892	99	267,479	100
Respiratory diseases (Tuberculosis, pneumonia and others.)	..	..	234,308	103	338,669	140	400,527	166	487,319	180
Leprosy ..	Not available.		Not available.		Not available.		Not available.		Not available.	
Crude birth rate (per 1,000) ..	36·06		39·52		32·98		35·99		34·5	
Crude death rate (per 1,000) ..	38·60		33·20		30·84		26·85		22·0	

basic science directed towards a comprehensive programme of community service. The following scheme is given to indicate the major functions of social life and the place which should be assigned to public health:

It will be evident that when maintenance of health and prevention of disease are aimed at in the programme of social welfare, the cure of diseases gradually becomes less voluminous in proportion to the rate of progress in the utilization of scientific tools for the physical, mental and moral well-being of the community. It is to be noted that here, as in many other spheres, scientific progress in the abstract has often out-distanced concrete achievement. The knowledge about the prevention and cure of many diseases and the maintenance of positive health and prolongation of life has been known throughout the world, but its application has lagged behind at different levels in different countries. The co-ordinated planning and technique of socialized medicine in Soviet Russia for 20 years have out-distanced the piecemeal achievements of England through 100 years. In Soviet Russia, the health of the individual is the concern of the State and of Society as a whole. Indeed, the Soviet Union is the one nation in the world which has undertaken to set up and operate a complete organization designed to provide preventive and medical care for every man, woman and child within its borders. Russia's example in the sphere of health protection has stimulated the Western European countries and America to consolidate their previous disjointed efforts into a cognate whole towards the ideals of sociological medicine.

'The failure to establish scientific methodology in determining tools for community welfare is one of the chief factors responsible for the present social lag throughout the world' (J. B. Grant). In public health administration, as in laboratory experiments, the principle of 'observation of natural phenomena and their confirmation through controlled experimentation' should be followed. Research, surveys and social experiments must be carefully blended in evolving the method of approach to a public-health-social problem. The evolving of practical methods requires sound economic considerations and proper training of the necessary personnel and their organization requires adherence to sound administrative principles, the securing of popular response and intelligent participation as well as the co-ordination of the inter-related spheres of governmental activity. Planned co-ordination between research, training and administration is an essential desideratum.

The essential *principles of sound public health administration* refer to (i) the necessity for the administration of the different health functions being undertaken for the whole community by a single governing body and not for different sections of the community by several governing agencies, with necessary co-ordination between inter-related sections; in other words, there

should be 'centralized direction and decentralized activity'. The administration must provide for technical supervision and periodic appraisal of the efficiency of the organization. (ii) Successful administrative procedure results only from scientific investigation and demonstration of organizational methodology in the measures whereby knowledge can be applied in practice to groups of population. The proper training of the necessary personnel in applying the methodology is an important requirement. (iii) Successful administrative procedure must be based upon sound financial considerations and practicable economic budgetting suited to the area and the population. Where cash purchase of health reform is difficult, the available cash may be utilized for technical guidance and supervision and the citizens may be encouraged to offer trained voluntary labour (= payment in kind), which is the largest item in cash purchase. (iv) Successful community utilization of knowledge for public health reform and medical protection requires a certain level of politico-economic progress and education. Health of the people is achieved through the people being themselves possessed of adequate education in, and practice of, health knowledge. (v) The securing of co-ordination between the related spheres of social services, owing to their mutual inter-dependence. (vi) In order to ensure better working and to avoid mistakes in local effort, *the whole design* of a public health planning must be before the mind from the beginning. Any effort, however small and localized, can confer benefit, if it is designed in relation to the scheme as a whole.

The Trend of Public Health Progress in British India

It is needless to point out that political events and social deterioration disorganized the systems of Indian Medicine even before the European powers came into touch with India. By 1800 A.D. the British were firmly organized as the rulers of this sub-continent.

The beginnings of the Indian Medical Service may be traced to 1600 A.D. when the Company brought in British doctors as ship's surgeons. Between 1763 and 1766, a regular service was created and was divided into civil and military. These doctors, who had to work under great difficulties, carried the torch of Western medical science from place to place. Assistants were at first trained as dressers, apothecaries and general hospital helpers—the fore-runner of highly trained subordinate services of later times. The first Medical School was opened in 1822 and a Committee on Medical Education was appointed in 1833 which led to the establishment of two Medical Colleges in 1835. The qualifications of the latter were recognized by the Royal College of Surgeons, London, in 1845. We do not find any noteworthy

progress in the first half of the 19th century except in the introduction of Jennerian vaccination in 1803 and the passing of the Indian Quarantine Act, 1825. The British rulers at this time were more concerned with the health of the army and of the Europeans in India. There was no evidence of any repercussions of the progress of scientific knowledge on the economic progress, the dawning and growth of social consciousness or the experiments in environmental sanitation.

The very active period of fundamental advances in science in Europe in the second half of the 19th century and the concomitant political and socio-economic progress which helped to establish hygiene and preventive medicine on a firm and practicable basis had rather poor repercussions in India. In the sphere of research, which was entirely in the hands of the British workers, half a dozen names stand out prominently, viz. Lewis (1872) described *Filaria sanguinis hominis* and *Trypanosoma lewisi*, Vandyke Carter (1877-78) described the causative organism of Indian relapsing fever, Evans (1880) described *Trypanosoma evansi*, Cunningham (1885) described certain bodies in Delhi boil which were later confirmed by Leishman and Donovan (1903) as L.D. bodies, Koch (1883) confirmed the identity of *V. cholerae* in Indian cholera, Haffkine (1895) introduced cholera vaccine and Ross (1897) discovered the transmission of malaria. The major part of our knowledge in the scientific sphere in India up to the end of the 19th century was due to the work of a few scientific departments of the Government and of a few isolated workers who devoted their spare time to pursuits which interested them. In quite a number of cases such devotion to work was discouraged by the heads of departments, as happened in the case of Sir Ronald Ross. Since all the important posts were held by British members of the Imperial Service, Indians got very little opportunity for working into the mysteries of the causation of diseases and the problems of their prevention and treatment. The first Pasteur Institute was opened at Kasauli in 1893 and the Haffkine Institute was started in Bombay in 1899 for the manufacture of prophylactic vaccines against cholera and plague. The Imperial Veterinary Research Institute was established in 1893. The Indian Institute of Science at Bangalore, which is now taking a prominent part in biochemical investigations, was started in 1896. Antiseptic surgery was introduced between 1876 and 1881.

In the sphere of education, the first three universities were founded in 1857 but these and others founded later were mainly of an affiliating type rather than serving as centres of teaching and research. The medical teaching was chiefly controlled by the Indian Medical Service, although loosely connected with the Universities. State medical services were composed of military and civil officers, besides a growing independent medical profession and the followers of the ancient systems of Ayurveda

and Unani. 47% of the officers in the Indian Medical Service numbering 220, which was treated as War Reserve, were posted to the civil side, all the important teaching and administrative posts being statutorily reserved for them. In the sphere of public health, as has been stated before, most of the efforts were chiefly directed to the safeguarding of the health of the army and the Europeans in India and to the prevention of infection through transport channels, land or water. It is said that the 'real history of sanitary organization in India' began in 1859 when a Royal Commission was appointed to report on the sanitary state of the *army* in India. This Commission suggested the appointment of a Commission of Public Health for each presidency 'to give advice and assistance in all matters relating to public health and to exercise supervision over the sanitary condition of the population, both European and Indian. 'The primary object of these provincial commissions was to try to diminish sickness in the army; but this was recognized to involve (1) the sanitary improvement of Indian towns, (2) the prevention and mitigation of epidemic diseases, (3) constant observation of the sanitary condition of the population and the reports of the prevalence of sickness, (4) the construction of works of drainage and water-supply, (5) the proper carrying out of sanitary rules and regulations, (6) the preparation of codes and rules adapted to the special sanitary requirements of the army and of the civil population, and (7) the submission to the Government of India of plans for co-ordination and supervising the whole sanitary administration of a presidency.' No doubt the rapidly advancing sanitary progress in England at the time and the occurrence of excessive disease and deaths in the army dictated the inception of these ideas, but it is significant to note that the Government of India at that time 'did not favour a general sanitary system owing to the financial and administrative difficulties of introducing this into India'. The following are some of the important public health Acts of the period:—Indian Lunatics Removal Act (1851), Indian Merchant Shipping Act (1859), Puri Lodging Houses Act (1871), Bengal Births and Deaths Registration Act (1873), Bombay Vaccination Act (1877), Calcutta Burial Boards Act (1811), first Indian Factories Act (1881), amended in 1891, 1911, 1922, Bengal Municipal Act (1884), Bombay Protection of Pilgrims Act (1887), Indian Railways Act (1890), Pilgrim Ships Act (1895), Indian Epidemic Diseases Act (1897), Indian Lepers Act (1898), and Indian Glanders and Farcy Act (1899). The passing of the first Local Self-Government Act in 1885 relegated the task of the promotion of sanitation to local bodies and village unions. The beginnings of political and social progress were thus laid here. Maternal and infantile mortality attracted the attention of voluntary workers, which resulted in the establishment of the Dufferin Association for supplying medical aid to women in India (1866),

the introduction of modern nursing (1869) and the starting of a Women's Medical College at Ludhiana (1894).

It is significant to note that while the recommendations of the Royal Sanitary Commission in England (1869–71) were implemented by continuous efforts to apply the knowledge gained from the discoveries of the medical science and by persistent State action to educate the population in matters concerning health and to develop the environmental and medical services, those of the Royal Sanitary Commission in India (1859) were relegated to the background as being inapplicable to the then Indian Community.

Forty years of the 20th century have seen enormous advances in medical knowledge and its application by the State in England and other Western countries, along with simultaneous social evolution and political progress. Each of the new discoveries in the various sciences opened up a new vista of possibilities for applying them to the well-being of man. The consolidation and co-ordination of the piecemeal measures of the previous century have helped to develop medicine as a social science and to restrict and defeat disease wherever it shows itself, to prolong human life wherever it exists and to build up and conserve health as such in the home, in the school, in the factory and in the field.

Let us glance, for a moment, at what was taking place in India during this period. In the sphere of medical research, Leishman and Donovan's discovery of the Kala-azar parasite (1903), the report of the Plague Commission (1904) and the discovery of Urea Stibamine by Brahmachari (1920) may be considered as important landmarks. Since the publication of the Report of the Plague Commission (1904), which advocated the reconstruction of the Sanitary Department on a wide imperial basis, and with the establishment of adequate laboratory accommodation for research, teaching, sera and vaccine production, the strengthening of it by the recruitment of scientific experts and the placing of the new service under the Government of India in respect of both the executive and scientific duties, the amount of medical and veterinary research carried out in about a dozen and half research institutions, in various spheres, has not been small but most of them have not been dictated by particular unsolved public health problems and even when their results have been made known there has been very little attempt to apply the scientific knowledge to the eradication of prevailing maladies and to the physical well-being of man and animals. The establishment of the Bacteriological department in 1906, most of whose workers belong to the Indian Medical Service, and of the Indian Research Fund Association in 1911 'with the object of ensuring a continuous supply of young workers of adequate calibre and of attacking such medical research problems as awaited solution' are to be considered as important steps in solving the urgent public health problems, although the manner

of their working is still defective and is capable of improvement. It has to be remembered in this connection that the Indian Research Fund Association is a much older body than the Medical Research Council in England (1920) which is doing excellent work.

In the sphere of medical education, a University grade and a lower (or school) grade of education have been prevalent since 1857, but the latter qualification is neither recognized by the British General Medical Council nor the Medical Council of India. The new University Regulations of 1906 tried to improve medical education and advanced studies, both of which need immediate reform to suit the requirements of the national health policy. The Indianization of some of the professorial chairs at medical colleges began in 1911 and the Indianization of the hospital staff began as late as 1923. The establishment of the Calcutta School of Tropical Medicine (1920) and of the All-India Institute of Hygiene and Public Health (1932) has made it possible for the post-graduate training of medical and public health personnel. The Medical Council of India (1933) aims at improving and standardizing medical education in India. Twelve Medical Colleges and 27 Medical Schools are now turning out about 700 graduates (including 100 women) and 1,500 licentiates per annum, the same number as England and Wales are turning out for 1/9th of the population of India. The requirements for the annual output of qualified doctors in India are far more than this. The total number of qualified doctors in India is 42,000 or one doctor per 10,000 population and that also very unevenly distributed, in contrast to England's one doctor to 800 persons.

During the latter half of the 19th century, the policy of the Government of India with regard to sanitation and sanitary staff was marked by vacillation but more activity was noticeable since the beginning of the 20th century. The Government of India formulated a forward sanitary policy in 1914 (Resolution dated 23rd May, 1914), when some useful principles of sanitary organization including research, sanitary surveys, urban sanitation (conservancy, water-supply, drainage) and town planning, rural sanitation, health education and the combating of epidemics, were laid down but they have hardly been properly implemented. The political and social awakening of the earlier years of the present century was followed by the Government of India Act of 1919 which accepted the principle of provincial autonomy. This led to the transfer of medical administration, including hospitals, dispensaries and asylums, and the provision for medical education, together with public health, sanitation and vital statistics, with certain reservations, to nominated ministers. Extra-provincial, inter-provincial and international matters, together with legislation for the control of epidemics were reserved by the Central Government.

By this time, informed public opinion began to demand more expenditure on public health. In spite of this demand, nothing more than a skeleton staff could be employed—being too inadequate for dealing with large populations and areas entrusted to them. For example, in Bengal, a Health Officer was put in charge of a district and a Sanitary Inspector with a Health Assistant and a Vaccinator was posted to each *thana* (1927). In most areas, the latter were expected to look after a population of 60,000 or more, living in 170 villages spread over an area of 80 square miles or more. In some areas, the same staff were expected to look after 120,000 people, living in some 800 villages covering 400 square miles.

Measures for the improvement of hygiene in industrial areas began to be taken since 1911—Indian Factories Act (1911), Indian Mines Act (1923), Workmen's Compensation Act (1923), Bombay Maternity Benefit Act (1929), Tea Districts Emigrant Labour Act (1932) and Employment of Children Act (1933). In spite of these, occupational hygiene is still a neglected subject in the Health Departments of the provinces. The Royal Commission on Labour (1931) recommended quite a number of public health reforms in labour areas and the co-operation of the League of Nations also stimulated the progress to some extent. Provincial Municipal Acts passed during this period, aimed at improving the sanitary condition of municipal areas but they have hardly developed any successful methodology of work and their administration is, in a large majority of cases, extremely defective. Legislation against food adulteration came in 1918-19. Attempts have been made to stimulate maternity and child welfare work since the beginning of the century by various non-official and official organizations by offering facilities for the training of medical and auxiliary personnel and for research. The maternal and infant mortality is still appalling.

Since the Indian Medical Service has until lately been responsible for looking after the curative and preventive aspects of public health in India, it will be noticed that many measures which were undertaken in India from time to time were but poor imitations of what was being done in England. Most of the public health expenditure has been made in urban areas, while rural health has been severely neglected. From a consideration of various factors, we are of the opinion that India stands now, from the public health point of view, where Great Britain stood 100 years ago, U.S.A. stood 75 years ago and where Russia stood before the Revolution.

Although 90% of India's population are still illiterate, various socio-economic and political factors helped them to demand public health reforms. The extension of franchise by the grant of Provincial Autonomy in 1935 has created a demand for social welfare in the modern sense and various Provincial Governments are seriously considering the planning of public

health and social welfare in their respective territories. The Government of Madras is the only Provincial Government which has passed a Consolidated Public Health Act (1939).

Any public health planning which is not based on sound scientific and proven principles is bound to fail. On the threshhold of further political and social progress in India, it may be useful to consider its various implications in their proper perspective. This is the only apology I have to offer for taking up the present theme for my Presidential Address.

The socio-economic position and its repercussions on Public Health

In considering the present public health position in India, one must remember that India is larger than Europe *minus* Russia; that she has 9 times the population of England and Wales and that her population has increased by over 250 millions within the last 90 years; that 90% of her population is rural in contrast to 20% in England, 47% in Canada and 50% in Japan; that 71% of the population are engaged in agriculture and that only 1% are employed in industries; that over 90% of the population is illiterate and that some of the social and religious customs are not conducive to good health. The urban population of British India amounts to 25 millions, out of a total of 350 millions.

The average per capita annual income in British India is £4-7*s*. or 1/15th of that in England and 1/18th of that in U.S.A. (Findlay Shirras). The monthly income per head, therefore, comes to about Rs.5, but the rural population earns less—Rs.39 per capita per annum or Rs.3-4 per month. From this, the average rural inhabitant has to provide himself with food, clothing and housing, pay the land revenue and very often interest on his loans for buying live-stock, seed, manure and other necessities. The quantity of arable land per person is too small and the quality of cattle too poor to provide him with the minimum requirements of a healthy life, while he cannot afford to improve the gradually impoverished soil. Underfeeding and unbalanced food necessarily reacts on the physique resulting in preventible sickness and lack of stamina. Dr. Aykroyd estimates that a minimum expenditure of Rs.5 to Rs.6 per capita per month is needed to provide an adult with minimum balanced nourishment. The percentage of taxation to national income in India is 10·1, in contrast to 8·7 in Switzerland, 9·5 in Canada, 13·3 in Australia and 25·6 in the United Kingdom.

The inhabitants of British India are stated to enjoy the briefest span of life, viz. 23 years, in contrast to Sweden's 62 years, Britain's 60 years, Germany's 58 years, Italy's 45 years and Japan's 45 years. The crude birth-rate per 1,000 in India is 34·5 (1937). The crude mortality rate per thousand in British

India (1937) is 22·4, as compared with 12·4 in England and Wales, 17·5 in Japan, 18·8 in Netherlands East Indies and 18·9 in Palestine. Of the 6·1 million annual deaths in British India (1937), fevers (in which are included malaria, enteric, kala-azar, tuberculosis, etc.) account for 58%, dysentery, diarrhoea and cholera together for 7·3%, respiratory diseases for 8%, infantile mortality for 24·8%, smallpox for 1% and plague for 0·5%. Infectious diseases like cholera, plague and smallpox, which have been almost entirely banished from the Western countries and Japan, still take as annual toll of 99,000, 28,000 and 55,000 lives respectively. The rate of decline in mortality from the diseases and from the vaguely defined category of fevers has been extremely slow, while in some cases, e.g. respiratory diseases, there has been a gradual increase. Child mortality rates at different age periods are from 3–5 times higher in India than in England. For the whole period 0–10 years, the death rate among children in India is 4 times as high as in England. Maternal mortality due to child-bearing exacts a toll of 4-5 times than in Western countries, 20% of the deaths being due to anaemia which accounts for a negligible fraction of deaths (0·05%) in England. 80–90% of these deaths are, therefore, preventible. It is estimated that about 30% or 3 million women are permanently or temporarily disabled in India as a result of pregnancy or labour every year. There are 150,000 lepers in India and over 2 million persons (40–70% of the population in some areas) are estimated to be infected with hookworm.

If the English death rate obtained in India to-day, there would have 2,766,049 fewer annual deaths (males—58, females—60), and the expectation of life would be 60, instead of the present 23 years. The sickness rate in England, entailing incapacity for work is 2% of the population. Even if we take the rate as 4% in India, the number of people constantly sick would be somewhere near 11 millions, chiefly through lack of medical protection. No work has yet been done in India to indicate the sickness rate in the general population. The sickness rate among the British troops in India is, however, 12 times, while that among the Indian troops is 10 times that of the death rate. If this basis of calculation is taken, the amount of sickness in the general population and the consequent economic loss due to loss of wages would be enormous.

Of the 6,500 curative institutions, 3,000 hospitals with 95,000 beds and 3,500 out-patient dispensaries are attending to 35 million new and old patients annually. 925 of these institutions are voluntary, the rest managed or aided by the State. Of 6,407 medical officers who are manning these institutions, 220 are I.M.S. Officers occupying the senior posts, involving an annual expenditure in pay and allowances, excluding pensions charges, of about Rs.60 lakhs; 41 are non-I.M.S. Europeans, 740 are missionaries; 105 are military assistant surgeons, 1,054 are Civil

assistant surgeons and the rest licentiates or sub-assistant surgeons. The number of doctors employed in public health duties is 1,206 or 1/5th of that employed on curative services, of which only 217 possess public health qualifications. A little over 50% of the 247 districts employ a Medical Officer of Health, the rest still remain unprovided with. This is also very unevenly distributed. Over 50% of the total budget (curative and preventive medicine) is consumed by the medical staff. The total number of registered doctors is 42,000. The number of students who qualified in 1936-37 were 965, of whom 100 were women. About 12,000 medical students are receiving instructions in the year. There are 3,697 nurses in India, of whom only 211 are employed in rural areas.

The average area served by each hospital or dispensary varies from 24 sq. miles (Delhi) to 1,327 sq. miles (Baluchistan) and the average population served by each of these institutions varies from 11,305 in Baluchistan to 81,087 in U.P. The per capita expenditure on medical relief varies from one anna in U.P. to Rs.1-2-5 pies in Delhi. The expenditure in urban areas is nearly three times that in rural areas.

No planning for the health uplift of a community is possible without a consideration of the topography, soil study and the raising of food, weather conditions, population (men and cattle), water-supply, drainage, industry, education and economic and cultural backgrounds of the community. A survey of these factors is necessary before any planning is undertaken. It will be found that, in most spheres, the deviation from physiological health is related to problems connected with housing, clothing, physical cleanliness, drinking-water supplies, disposal of sewage, household refuse and manure, and the contamination and poverty of foodstuffs. The backwardness of India in the proper evolution of public health must be accounted for either by the progress of science not being applied to the prevention of disease as it has been done in advanced countries or to a wrong application of the same. Before we proceed to suggest recommendations, it is necessary to ascertain the causes of the lag in India and how they can be remedied.

Causes of the Lag between Science and its Applications in the Improvement of Public Health in India and some Suggestions for their Removal

1. *Absence of any national health policy.*

As has been pointed out before, in England there has been a persistent endeavour to apply the knowledge gained from the discoveries of the medical sciences, in the course of the past 100 years, to the social, educational, economic and hygienic well-being of her citizens. The advent of the British rule in

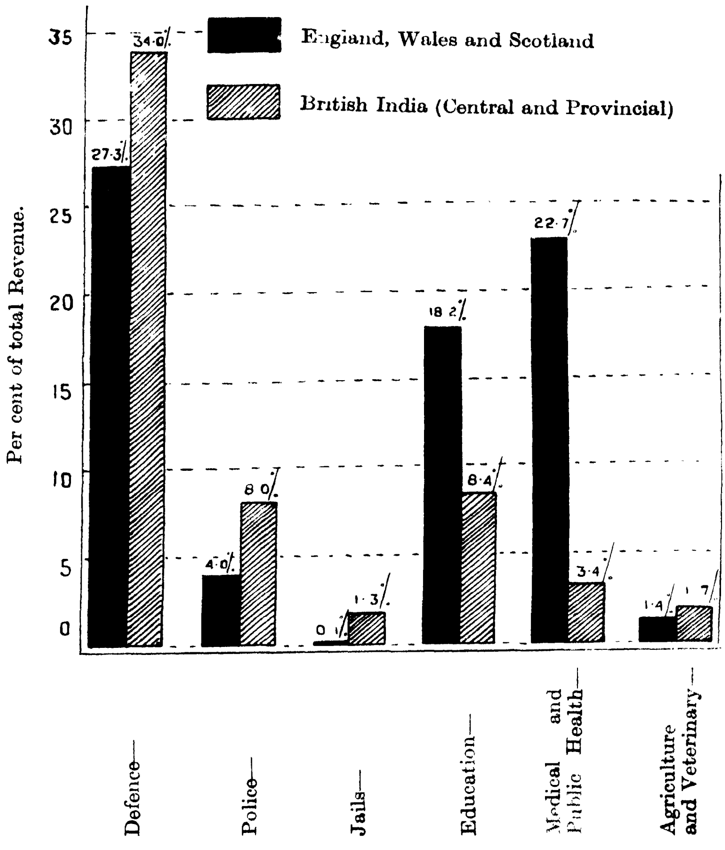
India coincided with the differentiation of science and its resultant industrialization in Europe. Instead of a continuous drive towards medical protection, health education and the provision of environmental services as in England, the administration in India showed a *laissez-faire* and vacillating policy. The medical and sanitary administration was bossed over by a Civil Service whose chief concern was to govern and to maintain law and order, without any perspective towards a co-ordinated development of the social services, such as education, agriculture, co-operation, public health, etc. Most of the personnel of these services appointed to look after the medical, public health and social services had no specialized training in the particular branches of the craft and hence there was little desire in them to utilize the scientific knowledge and discoveries of the times towards the betterment of the health and physical well-being of the population.

The medical personnel responsible for guiding the policy or for administration came and still comes from a highly paid service which has been primarily meant for the Army. Here also special technical knowledge and training were not considered to be the criteria for appointment in a particular post carrying a particular object, with the result that a man who began, for example, as a teacher of Anatomy was considered competent to be successively appointed a Divisional Surgeon, a Port Health Officer, a Radiologist, a Teacher of Medicine and so on. This principle is still being followed in the Imperial and Provincial Medical Services to the great detriment of the working machinery. The continuance of this system even in the 20th century when it is realized that medical progress cannot be possible without special training and competency accounts for a large measure of backwardness in medical and public health planning in India. This is the reason why Research and Medical and Public Health education 83 years after the establishment of the Universities in India are still hopelessly backward, as compared with other progressive countries. It is not my purpose here to underrate the excellent services rendered by the research workers and administrators of the previous generation who introduced Western medical science into this country and developed it, but there is no technical justification for its continuance in the present century, when there is a sufficient number of highly trained technical workers available in the country who can replace the superior services entirely without any loss of efficiency and run the organization at much less cost. In fact, the whole system of administration needs to be remodelled to suit the new conditions and requirements.

It has been pointed that there was hardly any public health policy until the reforms of 1919 and 1935. These reforms have no doubt stimulated a desire for progress but it is being hampered by the lack of a planned programme and policy, a hopelessly

inadequate amount being earmarked for medical relief and social services (*vide* histogram below), by the continuance of a top-heavy

Histogram showing some items of State Expenditure in percentages of revenue in British India (Central and Provincial) and England, Wales and Scotland. 1938-1939.



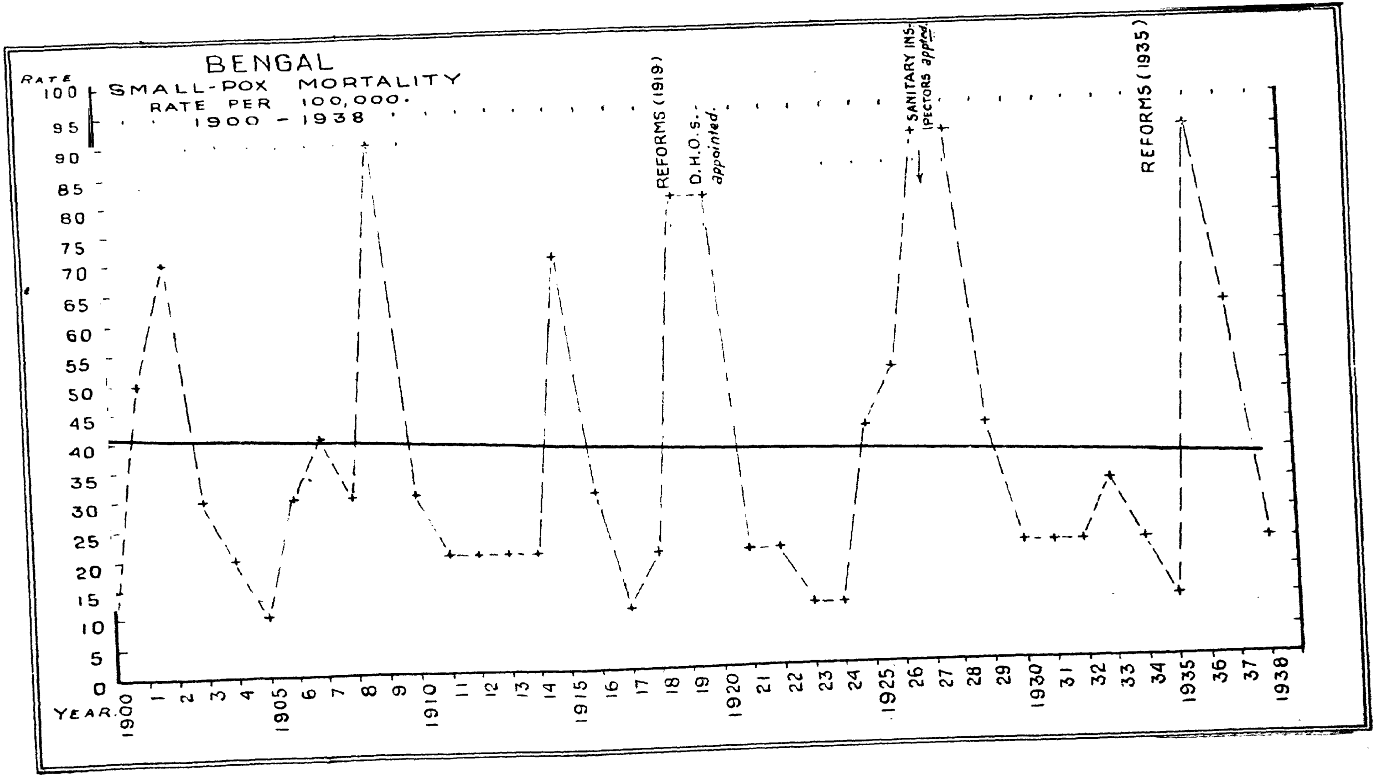
N.B.—No comparison has been made of figures relating to India with those of England and Wales in other fields of governmental activity, for the administrative set-up is so different in the two countries that they are not comparable.

administration without efficiently trained technical personnel and by the poverty of ideas in the administrators themselves. There is still considerable lack of co-ordination among the various

interdependent branches of administration which are concerned with a forward health policy and social progress of the population. Administrative procedures are often applied which are not based upon sound economic considerations and financial budgeting within the economic means of the population. The result has been that although some fragmentary public health measures have been undertaken in urban areas, the rural population has been hopelessly neglected, with the result that the villager in India to-day is no more benefited by modern science than his forefathers before the advent of the British rule.

2. *Violation of the essential principles of sound public health administration.*

India's lag in the utilization of science for the medical protection of her citizens through organized community effort is due chiefly to the absence of any national policy based upon defined principles. In most cases, all the six principles enunciated on pages (10) and (11) have been violated. The backwardness of India in health matters does not seem to be due so much to economic causes, ignorance or lack of medical facilities as to the lack of efficient public health and medical organization based upon the investigation of the most effective and economic methods of *applying* the results of scientific knowledge to the requirements of large units of population. It is true that Great Britain spends Rs.15 (1931) and U.S.A. spends Rs.30 (1932) per capita on medical and public health protection, but a comparatively much better result has been obtained in improving the situation in the Dutch East Indies with a per capita expenditure of 4·8 annas and in the Philippines with a per capita expenditure of 5·25 annas, in comparison with India's 3·5 annas (1931). For example, with a staff of 2,523 vaccinators (excluding Calcutta with 66 vaccinators) in Bengal, where Jennerian Vaccination was introduced as far back as 1803 (first in Asia) deaths from smallpox during the last ten years have numbered 166,000 (*vide* diagram below), whereas with a staff of only 150 vaccinators in Java, which has a comparable topography and population, the total deaths, mostly from imported cases, have been limited to 9 during the same period. It is further claimed in official reports in Bengal that during the ten years 1929–1938 over 8% of the population were *successfully* vaccinated every year at a cost of 1 anna 10 pies per head. The evidence depicted on the diagram can only point to one thing, viz. a wastage of time and funds, in spite of a large staff, chiefly due to defective methodology, supervision and control. Similarly, lack of co-ordination between the watertight departments of Irrigation, Railways and Roads and Public Health is responsible for a large percentage of India's 15 million annual deaths from man-made malaria. Take the case of nutrition again; when the health authorities detect



BENGAL
SMALL-POX MORTALITY
RATE PER 100,000.
1900 - 1938
RATE
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
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YEAR.
1900
1
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1905
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1910
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1930
31
32
33
34
1935
36
37
1938
REFORMS (1919)
D.H.O.S. appointed.
SANITARY INSPECTORS apptd.
REFORMS (1935)

malnutrition and deficiency diseases in a group of population, the remedy will lie with a co-ordination of efforts of the Communications, Agriculture, Animal Husbandry and Co-operative departments but none of them has yet carried science to the door of the ryot as in Java, Philippines or Japan. In the absence of such co-ordination, the ill-health continues and remains uncorrected. This is because India has not yet developed adequate knowledge of successful methodology and its community utilization and because public opinion is not properly educated, with the result that inefficient methodology has resulted in uneconomic and inefficient administration leading to wastage of funds which could better be applied to other fields. Before co-ordination can be of value, the fields to be co-ordinated must have the necessary technical content to apply known knowledge for a common purpose to groups of population.

Thus it seems that lack of a scientific outlook and an inadequate investigation by the administrative authorities in developing suitable methods of organization and the lack of a policy to include both urban and rural populations in a cognate whole as regards planning have been more responsible for her present backwardness than anything else. All scientific fields are governed by determinable laws, or else they are not scientific. It is of the utmost importance, therefore, that this country should make a general survey of the state of public health and of its health equipment, evolve a methodology of approach by carrying out sample experiments in different areas to understand the reciprocal co-ordination between the inter-related departments and its financial implications and, based on such findings, construct a coherent plan for a medico-social policy, fixing, year by year, the stage to be reached and securing the financial resources, in cash and/or kind, and trained personnel required for the purpose.

I shall cite a recent example from China (1934) when she was faced with developing methods within her economic resources. The help of the Peking Union Medical College was secured in developing the methodology of *School Health* on two economic standards. An 'A' service to demonstrate technical measures common in the West was provided entirely through cash purchase at a cost of 2·41 Chinese dollars (= Rs.2-6-6) per school child per annum. This, however, was impracticable of extension under Chinese economic conditions. Consequently, a 'B' service was developed at 64 cents (= 10as. 3p.) per school child per annum, which was economically practicable. The latter programme was developed on the basis that the essential measures should be undertaken by the voluntary effort of the teachers and pupils themselves and that cash purchase should be limited to provision of supplies and of technical supervision by the

medical officer and the school nurse. This applied to each of the three administrative sections, viz. Sanitation, Medical Service and Health Education. The practical essentials were water and sanitary toilets in Sanitation; routine appraisal measures of the individual pupil's health and prophylactic vaccinations under Medical Service, together with the correction of gross remediable defects; and the integration of healthful living and of health knowledge with actual living of the pupil in Health Education. It was shown that responsibility for the bulk of routine for the School Health Service could be placed upon the teachers and the pupils, provided two essentials were adhered to, viz. participative training of the teachers at a Demonstration Centre or a Science Institute and provision of adequate supervision of the established routine by the medical officer and the nurse. Thus it was possible to undertake the bulk of the essentials of a School Health Service through local voluntary effort, instead of cash purchase which was made available for technical supervision and medical supplies. This principle can easily be applied in India in many departments of public health where a complete cash purchase is not possible at the present moment, by securing the co-operation of the inter-related sections of social services.

If Great Britain can spend 18·2% of the revenue for education and 22·7% for medical protection, India should be ashamed to spend the insignificant percentage of 8·4% and 3·4% respectively of the revenue on these heads. Agriculture and Animal Husbandry may be less important in highly industrialized Great Britain, but it is of such vital importance to the health and life of the chiefly agricultural Indian population that a paltry expenditure of 1·7% of the revenue is scandalous. Rural hygiene, at least in its peripheral units, must be treated as a co-ordinated part of Rural Reconstruction, because rural health is very intimately bound up with the other economic and social factors pertaining to the improvement of the socio-economic status. Thus the departments of industries, irrigation, fisheries, co-operation and communications actively co-operate in other countries, with the public health programme in raising the stature of total health. It is a matter of great regret that these departments have hitherto failed to secure the necessary help and co-ordination in India. A national effort requires the pooling of all the available resources of the nation. The failure of such an effort has resulted in the neglect of proper drainage of the soil and the resultant creation of man-made malaria and in the development of communications without due regard to the requirements of marketing of agricultural produce and of the supply of medical aid to rural areas. It will thus be seen that, in national planning, any departmental planning must form an organic part of the total requirements.

In the maintenance of health, the State must provide for a social machinery to assure living standards adequate for the purpose. This refers to the improvement of economic status, nutrition, housing, physical fitness and recreation, co-ordinated with education and social assistance. Hardly any system of *social assistance* has been developed in India. Social assistance includes old age and invalidity pensions, compensation for physical injury or disease in the course of work, sickness benefit, unemployment benefit, etc. It must be remembered that in Great Britain, the National Health Insurance Scheme, which provides for medical assistance and other benefits in cash or kind to over 15,000,000 people between the ages of 16 and 70 years, is the largest health service outside the activities of the local bodies, which assume much more inclusive public health and social protection than in India. Prevention of disease includes impersonal services like food and drugs control, water-supplies, sewage disposal, etc., and the control of communicable diseases. The necessity for medical relief comes in where the efforts of the State to maintain the health and to prevent diseases have failed. As such, curative medicine should occupy a comparatively small place in the national health programme. This includes personal services, such as maternity and child welfare, school health and occupational hygiene and the institutions for the early diagnosis and preventive treatment of diseases—hospitals, convalescent homes, sanatoria and work colonies, dispensaries and peripheral health centres. Unless the Indian administration views at public health from this angle, the lag cannot be made up.

3. *Backwardness of, and lack of methodology in, education.*

Sir George Newman (1939) has said that 'National health—in every country in the world, everywhere, and all the time—depends upon first the knowledge of science or art of medicine discovered, tested, verified, proved and then upon its *social* application by the medical practitioner, by the State, and by the people of that State. *Without that knowledge, there is no knowing, without that application there is no going*'. The better application of this knowledge by the State and its wider usage by an educated and disciplined people is now recognized to be essential to ensure co-operation with any health scheme and to build up an efficient and healthy people. The lack of an aim and methodology in general education has resulted in wastage of effort and achievement of results in obtaining the necessary scientific outlook and in the intelligent participation and practice in social fields. Science is taught in a perfunctory manner in schools and the pupils seldom practise health and participate in public health activities. There is not a single official school nurse throughout India, whereas England employs 5,413. In the

same ratio, India would need 38,017. How can one expect to achieve results in India, if only 8·4% of the revenue, in comparison with Great Britain's 18·2% is spent for education and when teachers are not properly trained in the participation of public health work even for the school population, not to speak of the general population? A thorough overhaul of the general educational system has got to be fitted into the map of national planning.

4. *Defects in the training and supply of technical personnel.*

State Medicine has been defined as 'the rendering available for every member of the community, irrespective of any necessary relationship to the conditions of individual payment of all the potentialities of preventive and curative medicine'. The next in order of importance in health planning after developing the methodology is to train the appropriate categories of personnel in order to put into effect the methods for the whole population. The quality of medical care depends upon an intelligent interpretation of the correlation of scientific knowledge in its application to the needs of the individual. This can be accomplished only by trained and experienced personnel who realize the significance of that knowledge and have the discriminating judgment necessary for its proper use.

While continued endeavours have been made in Great Britain and other advanced countries since the early years of the present century to improve and adapt medical education to the needs of the changing socio-economic problems, the methodology of education in India has hardly kept pace with the changing environment and requirements.

The chief medical worker is the *physician.* He puts the teaching of medical science into practice and leads the people in their fight against disease and towards a healthier and more joyful life. The training of medical personnel, therefore, is an important matter in mobilizing them—for the type of service needed. Twenty-five years ago the medical curriculum in all civilized countries was directed to the study of morbidity; to-day the basic line is physiological. Medicine is now developing more and more into applied physiology. The new British medical curriculum (1938) has shifted the centre of gravity of medical education from the study of disease to the study of human health as the primary business of the student and has emphasized that a starting point for a medical course is not disease but health. The General Medical Council desired that '(1) throughout the whole period of study the education of the student should be directed by his teachers (*a*) to the importance of the measures by which *normal health* may be assessed and maintained, and (*b*) to the principles and practice of the *prevention of disease*; (2) instruction in normal reactions of the body to injury and infection, as an introduction to general pathology'. The Indian Medical

Council (1933) has also laid down 'that throughout the whole period of study the attention of the student should be directed by his teachers to the importance of the preventive aspects of medicine, and of measures for the assessment of normal health'. The ideas expressed above seem to be identical but their application is different, for none of the teaching medical institutions in India has so far put this principle into practice. In fact, the training imparted in this country seems to be exotic in character based on English methods and has frequently no bearing on the needs of the country or of a consistent public health policy. It is only a bad imitation of what is done in Europe.

Where medicine is so integral a part of the general life of the nation, the social sciences must be given a large place in the curriculum. A case of illness is to be discussed not only from the clinical or pathological point of view but in all its complexity including the social and economic factors involved. Thus sociology is coming more and more to the forefront in its manifold relationship to private and public medicine, to personal hygiene, to national health, to social and individual psychology, to the economic structure of the society and to public health administration. Unless the student realizes, during his period of training, that a knowledge of chemical, physical and biological phenomena of disease and of a grasp of the social and economic factors which influence the methods of dealing with sickness and prevention of disease are only tools which are being placed in his hands for service, he cannot be expected to be a useful doctor for the country. Health should mean more than the absence of disease; the spreading of disease should, therefore, become a social offence.

Sir George Newman's idea of a modern practitioner is that 'he should possess a preventive appreciation towards the wide field of prevention in general midwifery and surgery and that he should have a community consciousness and specific knowledge of the statutory obligations that he may possess'. If preventive medicine has to have a pervading influence in all parts of the curriculum, how is this to be imparted in the successive stages? From the very beginning the teaching of the clinical and non-clinical subjects may be brought closer together in their applied and public health aspects. It is not possible to introduce this unless the teachers themselves appreciate its importance and willingly co-operate in making it a success. So far as public health was concerned, the Peking Union Medical College in China tried an experiment (1934), which is worthy of consideration. As clinical clerkships are given to students in the hospitals to get an insight into the causation and pathology of diseases, in like manner public health clerkships were given to students for a couple of months at a Health Centre working in collaboration with the regional hospital. The students studied the cases in the field in all their clinical, epidemiological and social bearings

and control, and actually participated in the methods of application of public health procedures. This helped to remove the idea from the minds of the students that they had to deal with curative medicine alone in the hospital, as also after passing out. A close co-operation between the clinical and public health group of teachers and an arrangement for joint teaching were secured. It was found that when the students understood the epidemiological and social implications of disease or failure of health, both in urban and rural areas, they were more inclined to settle down in rural areas and thus began to render more useful service to the nation than in the past. This ('Permeation') experiment of public health clerkship might be tried in India not only to re-orientate medical teaching but also to encourage students to work in rural areas. Or, an experiment which was tried in Russia might be tried here, viz. of selecting students for admission into the medical schools and colleges from the areas where national health planning needed their services. Free-studentships and scholarships were offered to such students in Russia on condition that they practised in rural areas for three years. This is an alternative method by which the disproportion between the distribution of qualified doctors in urban and rural areas may be remedied. Once in three years, such doctors were required to undergo post-graduate instruction at the cost of the State, not only to stimulate the doctors thereby to contribute to advances in medical science but to assist them to place the new knowledge gathered at the disposal of the social, economic and communal needs of the society—nutrition, immunization, health education, physiological assessment, physical and mental welfare, etc.

The problem in India to-day is how to remedy the lag between scientific progress and its application to the benefit of the individual and the community, how to adapt our medical education to the needs of the changing socio-economic and political environment and how to train the necessary technical personnel for carrying out the national health programme and to supervise its various units. Let us try to estimate the number of doctors—institutional and public health—nurses, midwives, *dais*, dentists, pharmacists, sanitary inspectors, dressers, health assistants and publicity officers needed for an organization visualized as above.

We need three types of *doctors*—(1) practitioners for therapeutics (medicine and surgery) and general prophylactic workers, (2) public health physicians, and (3) specialists for the protection of mother and child. These may be considered as the officers in the army engaged in fighting disease but like every army the medical corps requires a large number of non-commissioned officers, such as nurses and technicians, without whom medicine will not fulfil its task. Health assistants, sanitary inspectors, midwives, laboratory technicians, dentists,

pharmacists' assistants, etc., may be included in the latter category. We need also an accessory type of personnel which consists of orderlies, hospital employees, ambulance drivers, etc. Lastly, the rôle of voluntary workers—men and women, boys and girls—affiliated to some social service organization should not be underestimated. The education and training of each of these categories of personnel have to be attended to in its theoretical and practical aspects.

There are 600,000 villages in India and, if we have to supply a qualified doctor, with public health qualifications, to a group of say 3 villages, we shall require 200,000 trained *physicians* to man the peripheral units of the rural medical relief *cum* public health organization. Besides these, we need better trained workers for the purpose of supervision or for supplying service which requires specialized knowledge and skill. Assuming that 10% of the total personnel would be engaged in supervision work, we need 20,000 supervisors. Besides these, specialized service may require another 10,000 highly skilled doctors. This means that if we are to reconstruct public health on a new basis, we should require at least 230,000 trained doctors of different categories. As a result of scientific medical training in India for the last 100 years the number of qualified practitioners is to-day only 42,000. If we have to go on at this rate it will take for us another 150 years to get the required number. Russia was faced after the revolution with the same problem. She was therefore compelled to quickly increase the number of medical students to get the required number of physicians. Between 1913 and 1933 the increase was 4 times. In 1913 the number of qualified doctors was 19,785, in 1924 it was 33,000 and it now exceeds 110,000. The training of other categories of personnel, which will run into several thousands, will also have to be thought of in terms of the developing needs of the situation in a given area.

Medical education will have, therefore, to be thoroughly reorganized and adapted to the new requirements. Social science must be given an adequate importance in the curriculum. It will not suffice for the student to get his training in the hospital wards alone but it should be extended to community fields, in order to give him an idea of the applicability of medical knowledge towards the maintenance of health and prevention of disease in the community. The university should not only arrange to train the necessary personnel but also help in evolving practical methods of solving the various problems and to extend those methods to the community. The appointment of a Chair of Medical Sociology and one of History of Medicine seems to be an urgent initial step.

As in medical relief so in public health, we should have field demonstration centres, urban and rural, in connection with

teaching. These will supply a student with a proper outlook about his responsibilities to the community, without which he is likely to be a misfit. It has already been said that the failure to establish scientific methodology in determining tools for community welfare is one of the chief factors responsible for the present social lag throughout the world. Successful methodology for community utilization of knowledge within economic practicability will also have to be taken up by the universities for investigation. So long as we cannot secure the required volume of personnel, the lag between this and the community utilization of knowledge can be considerably removed if we have at our disposal a successfully tried methodology for the application of public health reform and medical protection. For example, in spite of an insufficiency of trained personnel in Java, small-pox and cholera have been practically wiped out at less cost per capita and less staff than in India.

It will be pertinent in this connection to think of what is going to happen to the indigenous systems of medicine which have been prevalent in India since the ancient and mediaeval days. I cannot do better than quote, in this connection, the following extract from the Convocation Address of Sir Nilratan Sircar, delivered before the Andhra University on the 7th October, 1939: 'With the establishment of provincial autonomy in the provinces, efforts are being made to give official recognition to the Ayurvedic, Unani and Homeopathic systems of medicine. The basic sciences of chemistry, physics, biology, physiology, pharmacology, pathology and bacteriology are the same all over the world. The present tendency to register practitioners of various so-called systems of medicine, lacking systematic scientific training of any sort, is a move in the wrong direction. We do not call a barrister or an advocate now practising in India according to communal denominations. Science is progressive and must be the same throughout the world. The criterion of the right of a doctor to medical practice, or to the privilege of registration, must depend on the basic knowledge he possesses of the fundamental sciences of chemistry, physics, anatomy, physiology, pharmacology, pathology and of medicine, surgery, midwifery, and other cognate subjects. No system of medicine, Ayurvedic, Unani or any other, can get on without the help of modern basic sciences. There should be no spirit of communalism or opportunism of false economy concerning matters of life and death of millions of ignorant and helpless villagers whom we have failed to educate or elevate. The question of prevention of epidemic diseases cannot be successfully solved, unless scientific methods of proved efficiency are adopted. How can we apply all the different systems of medicine towards the end? The proper move should be to have only one medical science which has been worked out by the scientists all over the world, incorporating into it whatever good there may be in the

indigenous medical sciences of the country. If this is done there will be only one medical register in the country which should facilitate the control of medical relief and sanitation for the entire population. It is for this reason that I am compelled to discourage the teaching of the so-called medical systems, without the help of the basic sciences. If India is to achieve her place among the first rank nations of the world, she must advance with the help of modern sciences and she must discourage retrograde measures of the sort that are being encouraged in some of the provinces, without forethought and imagination.'

5. *Research and public health progress.*

Medical and Veterinary Research in India has been shabbily treated and badly organized. Researches have been carried out on many diseases in India but very few of them have been undertaken to solve specific health problems and, even when the results of such investigations have been made known, there has been little attempt to apply them into practice. For example, the Plague Commission of 1895 carried out excellent investigations into the epidemiology of plague; still 31 years after the publication of the report plague caused 28,169 deaths in one year (1937) and the Public Health Commissioner for India opined that unless cheap designs for rat-proof houses could be designed, as in Java, for rural areas, where 92% of the deaths occurred, the prevention of plague could not be effected. How is it that in one country the lag between knowledge and its application (Java) has been overcome and not in the other (India)? Likewise the Public Health Commissioner notes (1937), with regard to cholera, that 'If every Indian village were provided with a protected water-supply and were to practise a sanitary method for the disposal of refuse and night-soil there would undoubtedly follow a marked and permanent reduction in the incidence of bowel diseases, such as cholera, dysentery, diarrhoea and typhoid, whilst guinea-worm infection, which causes a large amount of suffering and incapacitation, would also be suppressed'. The installation of tube-wells has been suggested as a remedy. Further, it is noted that only 13% of towns with a population below 30,000, 56% having a population between 30–50,000 and 78% having a population of over 50,000 have a piped water-supply. The number of villages with protected water-supply is stated to be negligible. These diseases caused nearly 500,000 deaths in the year 1937. If only a fraction of the economic loss consequent on death and invalidity from these diseases could be spent in adopting methods which were developed by field research, this unnecessary wastage of human life could be prevented. But the lag could not be removed here, as elsewhere, owing to inadequate investigation and the adoption of a bold public health policy. A similar lag is noticeable in

the conservation of animal health in the interests of human health. It is needless to emphasize the importance of field enquiries in a country which is chiefly agricultural and where every variety of soil, climate, race, diet and habits is prevalent. The universities and their affiliated medical institutions have neglected to encourage applied medical research and have failed to keep a living contact with the needs of the country. A thorough reorganization of the educational system, particularly in its scientific aspects, is urgently called for.

Researches should be centralized in order to ensure co-ordination and avoid overlapping. The provinces may take up local problems, while the centre may take up problems of an all-India character for investigation. This necessitates careful planning and co-ordination of various schemes of research in all branches of science, whether pure or applied. Pure scientific research is as essential as that specifically devoted to the attainment of any medical, public health or industrial object. The detailed planning of research must be in the hands of those with the necessary specialized knowledge and they must be able to act without suspicion of political or racial influence. The formation of a National Research Council for India is overdue. With a view to harnessing science in the service of man, it is necessary to explore ways and means for extending the existing machinery of scientific education in the country, from the school to the university stage, develop applied scientific training and research, and, finally, to see that such research is undertaken with a definite end in view and not outside the ambit of planning for public health. The most useful investigation at the present moment should be directed to the extension of medical knowledge for actual utilization by the villager. The universities in India have hitherto failed to fulfil their research function, because of the service organization and of the multifarious obligations of the workers in affiliated medical institutions.

Hardly any investigations have been carried out in India on *occupational hygiene.* Industrial medical research can be divided into two categories:—(1) physiological research concerned with the study of the effect of environment and of occupation of the individual and (2) the organized application of science to the population in providing standards of medical protection for the maintenance of health and cure of disease and thereby increasing the output and welfare of labour. It is necessary for this purpose to organize fundamental 'pure' research at central or university laboratories and 'applied' research in the industry itself, thus establishing a channel of communication between fundamental science and its application. Industrial medical research is successful in proportion to its co-ordination with the national planned organization of science. This visualizes a horizontal all-India scientific planning organization, constituted as part of national economy from which various

special vertical functions would be derived, of which one would be industrial scientific research with a specific division for Medical, in so far as it relates to problems arising from the human factors of production.

Apart from research, the economic implications of health protection of the worker needs the development of a well-planned system of *social insurance.* The system of social insurance differs, as regards its thoroughness of protection and organization in different countries; it is more thorough in Soviet Russia than in the Western European countries. Before India wishes to adopt any one system, it is necessary to study the methodology of its applications in the field. This will save unnecessary complications and wastage of efforts in future.

Having devoted the first eleven years of my career to the bacteriology, pathology and clinical investigations of a number of human diseases, I realized the close relationships of social science to research when I took up tuberculosis as my object of study fourteen years ago. I got the first insight into the problem by a study of the epidemiology and pathology of the disease. Although some bacteriological investigations were taken up, they were undertaken with a view to solve related but unsolved problems. The problem as to how tuberculosis reacts to industrialization in an agricultural country is now engaging our attention. Since tuberculosis is a social disease, the investigation of the home conditions and environment of the cases cannot be left out of account in studying the disease. Thus I have been dragged from the laboratory to the ailing man, his home and environment, his place of work and the hazards to which he is exposed there, and to his habits, customs and movements. The study and prevention of such a disease need planning and team work for the elucidation of problems and extensive education and suitable administrative action by the State and Local authorities for prevention. The application of the results of research ought to be the duty of the people and the State.

6. *The supply of drugs and instruments.*

In spite of the fact that India abounds in all kinds of medicinal plants (Col. Chopra estimates the number to be 2,000) and in spite of the fact that many potent drugs had been used in India since the pre-Christian era, it is a matter of great regret and shame that no attention was paid to a rational and scientific investigation of the drug resources of India until lately by the Calcutta School of Tropical Medicine and still later by a few other centres. Although it is true that a few useful drugs have already been found, out of nearly 200 medicinal plants investigated by Col. Chopra and his collaborators, it must not be forgotten that it has taken 20 years for them to tackle 1/10th of the drug resources of the plant kingdom.

It is estimated that approximately 90% of the population of India have to take recourse to the use of indigenous drugs, partly because drugs manufactured by the Western system are more costly and partly because no arrangement exists for the medicinal treatment of the rural population.

Col. Chopra is credited with the statement that nearly three-fourths of the medicinal plants mentioned in the British and other pharmacopoeias grow in India in a state of nature and that others can be easily grown No attempts have, however, been made to systematically cultivate and study Indian medicinal plants for supplying the population with cheap drugs for the treatment of so many preventible diseases in India. For example, take the question of the supply of quinine. In spite of the fact that, in the absence of more permanent methods of eradication of malaria, the administration of quinine is considered to be the only feasible and economical anti-malarial measure in treating about 100–200 millions of the infected population, India produces barely 1/10th of her requirements of this drug and imports the bulk of it from Java at a higher price than the cost of production in India. Recent investigations have shown that 38,000 acres of suitable land are available in India for Cinchona cultivation which could yield seven times the quinine required for India. This is another illustration of how things are done in India. It is said that the cost of free distribution of quinine is very much higher than the price of the drug itself, the cost of the drug per individual being only four annas and its free distribution costing from twelve annas to a rupee.

The *laissez-faire* policy of the Government has resulted in the export of raw materials from India and to the import of finished products into this country, resulting in an economic drain. It would be interesting to know that during the year 1928-29, drugs exported from India amounted to Rs.42 lakhs, while the figure for imports was Rs.200 lakhs. Tea dusts of over 400 million pounds are annually exported at a nominal price, while it comes back to us as alkaloid caffeine valued at Rs.6,57,600. It is understood that caffeine could be easily manufactured in India at competitive prices, provided the railway freight of tea dusts is reduced. It is reported that the lag here had been the unwillingness of the Tea Associations of India in permitting the manufacture of caffeine from waste tea in India. If the State had a policy to foster the development of manufacture of indigenous drugs, they could have easily overridden these objections of an organization with vested interests. The same may be said of many drugs like nux vomica, belladonna, castor oil, etc.

The total consumption of drugs in India prepared by Western methods in 1938-39 was Rs.2,20,53,230, of which India produced roughly not more than Rs.75 lakhs worth of drugs, and to produce this quantity of drugs raw materials to the value of at

least Rs.10 lakhs had to be imported. India has to depend on foreign countries on the supply of basic chemicals for the manufacture of drugs, particularly alkaloids, organic and inorganic acids, coal and wood distillation products and various solvents used in the manufacture of synthetic drugs. Unless the coal distillation industry is properly organized, India will have to depend on foreign countries for the supply of most of the synthetic drugs, at a higher expenditure, which are needed for medical relief.

Thus, while the output of drugs manufactured by the Western method is small compared with the requirements, the vast proportion of the people, chiefly in rural areas, are compelled to use indigenous drugs prepared by Vaids and Hakims, 0·1% of whom possess the necessary training and scientific background. The responsibility for this widespread use of unscientific medicine lies in the lack of a planned programme to reach scientific medicine and tested drugs to the door of the humblest citizen. Attention should, therefore, be directed to the following immediate requirements which have been accentuated by the recent military blockades: (1) the manufacture of chemicals including solvents, (2) the production of synthetic drugs of known value, (3) an expansion of the investigation of Indian medicinal plants with a view to replace foreign drugs, including the study of Ayurvedic and Unani drugs and their standardization in known Western terms. This will be one of the means to supply cheap medicines to the population suited to the climatic conditions of the country, and (4) the cultivation of medicinal plants in suitable areas with a view to secure a standard yield of the active principles of drugs. The above investigations no doubt require extensive research by chemists and pharmacologists in close co-operation with the manufacturers. Naturally, no single institution is in a position to undertake this huge task. The Chemistry departments of various universities, the Pharmacology departments of the different medical colleges and various official and unofficial research institutes may be requested to take up the problem, according to a planned and co-ordinated programme, directed by a Central Advisory Board, consisting of the different categories of scientific workers, chemists, pharmacologists, botanists and industrialists. The State should come forward and take the initiative to set up the organization and to supply the necessary funds. As soon as the researches reach a certain stage, an attempt should be made to compile an Indian Pharmacopoeia, for without the standards laid down in such a publication the manufacture of the different medicinal preparations and their standardization will be rendered difficult and slow. It is firmly believed by many pharmacologists, botanists and chemists that India can be made self-supporting as regards her drug requirements and that the treatment of many diseases could thus be provided within the means of the Indian masses,

whose paying capacity is unfortunately very poor, provided there is a national planning in this regard and provided the necessary co-operation and co-ordination are forthcoming between various Government institutions, universities and non-official workers engaged in similar or allied investigations.

The remarks which apply to drug supply also applies to the supply of instruments. In spite of 150 years of contact with Europe, India has still to import most of her technical instruments and apparatus needed for the diagnosis, treatment and investigation of diseases. Compare this with Soviet Russia. In 1912, she imported 59% of the total value of drugs used; by 1934 the imports were only 3% of the total value; by 1940 she must be self-sufficient in this regard. By the middle of 1935, there were 2,500 X-ray apparatus of Soviet manufacture already in use; quartz lamps and diathermy apparatus of home production were also coming to the market; the output of satisfactory surgical needles and syringes was reaching a high figure; and by the close of the same year, a supply of some 850 dentists' chairs was proceeding from shops established a few months ago.

7. *Financial handicaps to progress.*

Modern public health, which is an integral part of the social services like education, agriculture, animal husbandry, co-operation and industries, has to be paid for. It has already been pointed out that the social services in India are starved at the expense of a top-heavy administration and a high expenditure on defence and police. The salaries in the superior services in India are often 3-4 times higher than those paid in France or Japan. The actual amount spent on defence and police in India is higher than what appears superficially to the casual observer. For example, the percentage of revenue shown as being spent on defence does not include the cost of Frontier defences and the heavy loss on strategic railways is stated to be shown under other heads. If these are included, the proportionate cost on defence will be much higher than what has been in Britain before the present war, in spite of the fact that India hardly possesses a Navy and an Air Force. The top-heavy administration here as elsewhere absorbs a major part of the budget. Similarly, 75% of the Union Board rates, at least in Bengal, is made to pay for the *chaukidars*, or peripheral police agents, leaving very little for putting into operation social welfare services in the villages.

The percentage of revenue spent on education in Britain is over twice, while that on preventive and curative medicine is nearly 7 times of what is spent in India. The following comparative tables of expenditure on certain social welfare services in England and Wales, India and Bengal will be found to be illuminating.

Comparative per capita expenditure on certain services in India and Bengal.

	India as a whole (Central and Provincial only) 1937-38.	Bengal. Provincial 1939-40.	Bengal. Municipal 1937-38.	Bengal. District Board 1937-38.
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
General Administration	0 7 6	0 5 0	....	....
Administration of Justice	0 3 0	0 3 6	....	....
Jails	0 1 3	0 1 0	....	....
Police	0 6 6	0 8 0	....	0 1 6
Education	0 7 6	0 4 6	0 4 0	0 1 6
Representation in Indian States	0 0 6	....	....	....
Audit	0 0 6	....	....	....
Tribal Areas (Defence from raids) ..	0 1 0	....	....	....
External Affairs ..	0 0 3	....	....	....
Medical	0 2 6	0 1 7	0 3 0	0 0 9
Public Health ..	0 1 4	0 1 4	0 2 5	0 0 9
Agriculture ..	0 1 4	0 0 6	....	....
Veterinary	0 0 3	0 0 1	....	....
Industries	0 0 6	....	....	....
	2 1 11	1 9 6	0 9 5	0 4 6
		0 9 5		
		0 4 6		
		2 7 5		

Comparative Expenditure on Social Services in England and Wales and Bengal.

Bengal—Provincial, Municipal and District Board (1937-38) as compared to England and Wales (1935).

	Expenditure on Social Services.		Annual per capita.		Percentage of total expenditure on Social Services.		Percentage of Social Services expenditure to total Provincial, Municipal and District Board expenditure (Rs.14,49,59,409).	
	England and Wales.	Bengal.	England and Wales.	Bengal.	England and Wales.	Bengal.	England and Wales.	Bengal.
	000 Rs.	000 Rs.	Rs.	Annas.	Per cent.	Per cent.	Per cent.	Per cent.
Education	1,41,74,40	1,71,60	35·5	6	26·25	48	10·70	**11·0**
Medical ..	31,76,53	76,78	6·5	2½	6·00	23	2·40	**5·0**
Public Health		58,94		1½		17		**4·5**
Total ..	1,73,50,93	3,07,32	42·0	10	32·25	88	13·10	**20·5**

Provincial Expenditure on certain Social Welfare Services in Bengal.

Bengal—Provincial, Municipal and District Board (1937-38).

	Expenditure on Social Services.	Annual per capita.	Percentage of total expenditure on Social Services.	Percentage of Social Service expenditure to total Provincial, Municipal and District Board expenditure (Rs.14,49,59,409).
	000 Rs.	Annas.	Per cent.	Per cent.
Education ..	1,71,60	6	48	11·0
Medical ..	76,78	2½	23	5·0
Public Health ..	58,94	1½	17	4·5
Agriculture ..	11,53	¼	3	1·0
Veterinary ..	7,22	⅛	1	0·5
Co-operation ..	11,61	¼	3	1·0
Industries ..	16,05	½	5	1·0
TOTAL ..	3,53,73	11⅛	100	24·0

It will be futile to plan a co-ordinated scheme of public health, as has been visualized here, with such an insignificant allocation to the social services. More money has, therefore, to be made available for them. There are *three ways* of finding out more money for the cash purchase of public health: (i) to make more allocations out of the existing budgets to the social welfare services, or (ii) to increase the income per capita and thereby the taxable capacity of the people, or (iii) to make use of both these methods. The second of these methods requires a thorough national planning in economic uplift and will probably require many years before a satisfactory result is achieved. Owing to the urgency of national health reform in India, however, it seems feasible to suggest some sources from where money may be made available. The first and foremost is the reduction in the scale of salaries in the superior services. A 'Rolls Royce administration' cannot be maintained in a 'bullock-cart' country, and so long as the population remains underfed, uneducated and without the minimum requirements for a healthy living, a racial discrimination in the services is no longer tenable. In many departments of social welfare, the salaries of the superior staff swallows up 60–80% of the

total departmental budget. This is a financially unsound policy and should be abolished. To take the medical services as an example: out of 364 Indian Medical Service Officers, who are meant for military duty, as many as 220 are employed in the Civil departments in the provinces and the Centre. Their salaries and allowances, excluding the charges payable in pensions, amounts to about Rs.60 lakhs a year, of which Rs.16 lakhs are spent in England comprising leave salaries, deputation pay, sterling overseas allowance, etc. In Bengal, the non-voted expenditure on Medical and Public Health departments amounts to Rs.8,73,833, of which Rs.2,19,749 constitute expenditure in England, out of a total budget of Rs.96,56,296 (1938-39). The principle of employing the members of a service, liable for transfer to military duty, without any regard for technical competency and continuance of tenure, interferes with technical progress and throttles the extension of public health measures to large groups of low-income population. While not belittling the contributions of this service in the past, there is no technical justification for continuing the system in the development, distribution and application of scientific knowledge in a poor country like India any longer. If continued further, it will only act as clogs to the wheel of progress. The Military Assistant Surgeons, of whom there are 105 in Civil employ, are in a similar category. Sheer national necessity compels us to propose drastic reductions in the salaries of the superior services in order to make more money available for the social services. As an example, it may be mentioned that the transfer of the I.M.S. Officers from Bengal will supply a Public Health Nurse to each *Thana* Unit, totalling 575. Such a transfer will not hamper the efficiency of the administration, in the least, if the existing services and talents now available in the country are properly trained and mobilized. The same holds good for other superior services. Besides this, there is much anomalous difference in the scale of salaries of the various services which are expected to do the same or a better type of job. For example, medical officers in charge of hospitals who do not possess post-graduate qualifications in public health or any other subject are given the same salary as District Health Officers with D.P.H. qualifications and are allowed to practise at the same time. Moreover, the District Health Officers have a non-pensionable service, whereas the State Medical Officers attached to hospitals have a pensionable service. This is not only an injustice done to the Health officers but also to the general medical profession who have to face an unfair competition. Moreover, if the honorary services of competent members of the general medical profession are secured for the hospital services, much of the over-head cash expenditure in curative medicine can be reduced. It will thus be seen that nothing but a thorough reorganization of the services and a

sound national financial planning will meet the needs of supplying the minimum requirements for a healthy living for the whole population. If India could manage to spend Rs.20 lakhs a day now to meet the military obligations of the present war and if lakhs of rupees could be collected in the provinces for War Purposes, it would not have been impossible to mobilize the necessary finance for a national planning in peace-time had there been a desire and a policy in the administration to pursue a forward programme.

8. *Lack of institutional planning.*

Hitherto, hospitals have developed in most countries in a haphazard fashion according to the dictates of charity or exigencies of situation regarding the occurrence of diseases. Modern medicine has made diagnosis and therapy of diseases not only a highly specialized procedure in many cases but a costly method beyond the reach of many individuals in the community. In order to offer such diagnosis and treatment, free or at a nominal cost, to those who need it, it is necessary to plan the institutions on a regional basis according to the incidence of particular diseases in an area. If the findings of the Bhopal survey are taken as a basis, only 4% of sick people in this country require specialized treatment in highly equipped hospitals with specially trained personnel. These findings may not apply to all areas and, therefore, each area needs to be surveyed. When this is done it will be found that costly institutions with highly specialized staff will not be needed in such large numbers as now, if the distribution of hospitals and dispensaries is planned in such a way that minor ailments are cared for at the peripheral dispensaries, ordinary hospitals take care of the intermediate categories of cases and the difficult cases are taken to the highly specialized base hospitals. What happens now is that the city hospitals, like those in Calcutta, which possess highly efficient and expensive staff and equipment, deal with all sorts of cases, involving not only in wastage of time of the specially trained staff but of money as well.

To reach medical aid speedily to those who need it and to transport them to larger institutions where the necessary equipment and skill are available, a suitable planning in the development of communications is absolutely essential. It is a matter of regret that communications have not been developed in India to serve the needs of sick population.

Further, the tendency to construct stately buildings for hospitals in this country, which sinks most of the funds in brick and mortar, leaving very little for equipment and efficient running and service, is to be deplored. Cheaply constructed

hospitals which can last for twenty years would tide over the initial stages of economic planning and pave the way for better buildings when money can be made available, but for this appropriate research should be undertaken. We hardly find any indications for this in India.

As first steps to remove the lag, every province should have a committee on hospital standardization and planning, on which the medical associations should be represented. It will be the business of such a committee to survey the needs and suggest suitable standardized plans for different categories of institutions. If this is done, it will be found to be not only less costly but the community needs will be more efficiently met *through proper zoning.*

9. *Lack of co-ordination between the inter-related administrative departments.*

The Department of Public Health or Social Affairs is intimately related to the Department of Rural Reconstruction, which again is related to the Departments of Education, Agriculture and Animal Husbandry, Industries, Communications and Irrigation. Owing to a lack of proper co-ordination between them, many excellent public health schemes never fructify, to the great detriment of the well-being of the population for whom they exist. The functions of the Finance Department are said to sit on files for as long as possible and to prevent expenditure wherever possible. In order to bring about this co-ordination, England had to establish a Ministry of Reconstruction in 1919 and China had to establish a Ministry of Co-ordination in 1929. In the State, the health programme is only one part of the great national programme. Therefore, all Government agencies are allies and all should work towards the same end. The State has only one purpose—to promote the welfare of all its citizens without distinction, to raise their material and cultural standards and to liberate them from the bonds of poverty, ignorance and disease. The physician or health worker in such a State is a specialist who knows about disease and who works towards the fulfilment of the general plan side by side with the other civil servants.

The establishment of provincial ministries of health and a federal ministry of health in India is absolutely essential as a first step towards securing this co-operation. It is desirable that in the provinces, the necessary co-operation between health (including housing, nutrition, physical fitness, maternal and child welfare, school medical services, hospitals and supervision of the medical profession), public relief and social welfare institutions should be co-ordinated or united in a single Ministry of

Public Health or Social Affairs, which keeps in close touch with the institutes of Hygiene and co-operates, as much as required, with the medical faculties. The Ministry should secure the opinions of an Advisory Board, preferably consisting of non-service people with special knowledge of health questions, on all important aspects of public health planning. The division and technical value of the work should be so directed as to secure the maximum of efficiency with the minimum of expenditure, which will again be guided by the principle of co-ordination, unity of action and adaptation to local conditions.

The question of a federal ministry of health in India has been mooted since 1920, but it has not yet been solved. The formation of the Central Advisory Board of Health in 1937 was a move for interprovincial co-ordination, but it is only an advisory body without any power to enforce decisions where attempts at co-operation fail. This necessarily entails some retransferance of power from what has been given to the provinces by the 1935 Act. Without an All-India Public Health Act much progress is not possible. Only one of the provinces (Madras) has passed a Public Health Act (1939), but unless the other provinces possess it, very little co-ordinated and standardized progress will be achieved. In other words, the federal and provincial governments should sit together to frame a scheme of national planning in public health and social welfare according to modern conception and within the economic competency of the people.

It will be too diffuse an attempt to visualize the financial implications of such a scheme on an all-India basis, but we shall try to present the underlying principles of a scheme for a province, taking Bengal as an example, because the population of Bengal approximates that of England and Wales and of Java, two countries with two different orientations.

THE PLANNING OF PUBLIC HEALTH IN A PROVINCE, WITH SPECIAL REFERENCE TO BENGAL

The League of Nations Report on Medico-Social Policy in rural areas (1939) lays down that 'Medico-social policy in country districts should begin by the organization of arrangements for *medical care*. This is the normal course of historical development for the protection of health, and it is but natural that the first step should be that of meeting the most immediate and keenly-felt need. The sick suffer, and to relieve them is a humanitarian duty; it is also the means of paving the way for preventive medicine, which, from the standpoint of public health, is more important than curative medicine, though as yet less appreciated by the public'. From what has already been said, it is evident

that the State must be responsible for all medical work, viz. curative (or clinical) as well as preventive (or social) medicine, for the training and provision of all cadres of personnel, and for all types of establishments and supplies. It is understood that the service should be provided without any charge to the people, and yet the total cost must be such as the people are able to bear indirectly through taxation. In India, for a long time to come, financial stringency may limit the extension of these services, but, provided a methodology is devised whereby the payment for the purchase of health can be made in cash and in kind, so long as the economic condition of the country does not improve to a sufficiently high level, a substantial degree of progress can be achieved. In some European countries, the public relief authorities pay selected general practitioners for attendance on the poor and, through the extension of sickness insurance and other forms of collective medical assistance, the sick are given access to the whole armoury of preventive and curative services. This has been found to prove less expensive in the long run for the responsible agencies. From what has been said before, it will be needless to elaborate on the individual items, but, in order that an efficient organization is built up, the State medical service must be operated 'with the discipline expected of a military machine and with the economic management associated with an industrial enterprise'. The success and efficiency of any group action depends upon organization and supervision. The traditional functions of the doctor, nurse, midwife, pharmacist, etc., and of traditional hospitals, clinics and health bureaus must be scrutinized and, if they do not fit adequately into the new scheme, they must be altered. If necessary, new types should be evolved to take the place of the old.

The *training and supply of personnel* is a very important matter. With regard to the vehicle and content of medical education, certain changes from traditional forms will be needed to suit the requirements of the organization dictated by modern State Medicine. Practical training of all classes of personnel would be undertaken in both the urban and the rural units, so that the finished products are able to take their place in the service without undergoing further special training, which will thus result in a saving of time and funds. Post-graduate and Refresher Courses are expected to keep the knowledge and efficiency of the personnel at the proper level.

In order to attend to the socio-economic factor, the public health activities must be linked with those of rural reconstruction, they being mutually interdependent for success in either sphere. 'Preventive and curative medicine cannot be separated on any sound principle, and in any scheme of medical services must be

brought together in close co-ordination.' The preventive measures may be divided into the following categories: (1) the development of a social machinery to assure living standards adequate for the maintenance of health, (2) health education, (3) sanitation of environment, (4) epidemiological control of communicable diseases, and (5) organization of early diagnosis and preventive treatment of disease.

The improvement of sanitation of villages is possible only when the sanitation of every house is improved. To appreciate the magnitude of this statement, we may quote some findings of a health survey in one of the units (Closepet) subsidized by the Rockefeller Foundation in India.

Twenty-five per cent of the families in this unit had an income under Rs.5 per month, 30% had a monthly income of Rs.5-10, 25% between 10 to 15 rupees p.m., 10% between Rs.15 to 20 p.m. and the rest above Rs.20 p.m 30% of the families had only one room, the rest more than one room. 1·5% of the houses were provided with latrines, the rest had no latrines. 70% of the houses had no windows and 25% of the houses were unfit for habitation. 50% of the houses were without drains and in 50% of the houses the cattle were kept in living quarters. In 40% of the houses the kitchen refuse was stored in the backyard and in 15% it was thrown into the streets. In 40% of the houses, the sullage water was led into the backyard and in 50% it was led into the street. There was very little provision for safe drinking water. In 30% of the houses the manure was stored in the backyard and in the rest it was sent out to the fields.

Naturally, in such a population as this the improvement of environmental conditions is beyond the competency of a health organization, unless there is co-ordination with other social services through a department of Rural Reconstruction, which comes forward to plan and co-ordinate the Social Services, of which Health is one. Even the Department of Rural Reconstruction will find it impossible to obtain the desired results unless the villagers themselves become health conscious, through persistent health propaganda and practice and come forward to participate in the health activities of Social Welfare Leagues established and managed by them. The participation of village headmen, school teachers, medical practitioners and officers of the respective State departments will help a long way towards achieving the object.

The results obtained in the Closepet Centre was very encouraging as regards the improvement of school hygiene, control of epidemics, vaccination, vital statistics and reduction of maternal and infantile mortality. It was shown that infant mortality among cases conducted by the Centre was 76 per

1,000 livebirths, as compared to 157 in cases conducted by the local *dais* and that the maternal mortality in cases conducted by the Centre staff was 1·8 per 1,000 births, as compared to 8·1 in cases conducted by the local *dais*. It has already been shown in India that public health can be profitably purchased *in the army and jails*. Among the British troops, the death rate has been reduced from 13·03 in 1900 to 2·15 in 1937 and among the Indian troops from 10·87 to 1·77 respectively. The death rate in Indian jails has been reduced from 32·80 in 1900 to 10·25 in 1937. The sickness rate has also been greatly diminished. These evidences should infuse us with a hope for the future, provided a suitable planning is made based on experimented and successful methods.

It is to be noted that these Rockefeller-subsidized Demonstration Health Centres do not deal with curative medicine; still the expenditure per capita comes to annas 12. Such an expenditure is beyond the competence of provincial Governments at the present moment. Each of the five peripheral units at the Closepet Centre (= 50,000 population) catering to the needs of 10,000 people, employ one Sanitary Inspector, one Vaccinator, one Public Health Nurse, 2 Midwives and 2 Peons, supervised by a Central Staff of one Health Officer, one Assistant Health Officer, besides 2 clerks.

As regards the implications of curative medicine we have no data to go by, except a statistical study spread over six years in Bhopal State. It was found that 83% of the total ailments were amenable to simple treatment, if given in time; that 13% needed hospital care and that 4% required specialized treatment. This means that in a population yielding 10,000 patients 830 cases would need attention for minor ailments at a peripheral dispensary, 130 cases would have to be taken to a hospital centre for care and that arrangements would have to be made for the remaining 40 cases for specialized treatment at a more highly organized centre. Besides these, beds would have to be reserved, at suitable centres, for the isolation of infective cases, incurable cases, convalescent cases, maternity and gynaecological cases and sick children. Tuberculosis, leprosy and mental diseases would need separate arrangements. The system of travelling dispensaries and subsidized rural practitioners has proved a failure in India; hence arrangements would have to be made for permanent units according to the varying needs of the population.

Organization of Provincial Social Welfare Services

The functions and divisions of a Provincial health organization are illustrated in the following scheme:—

Organization of Provincial Social Welfare Services.

Ministry of Social Affairs.

Director of Public Health or Social Affairs.

Department of Rural Reconstruction.

Co-ordination. ⟷ Dept. of Education.

Co-ordination. ⟷ Dept. of Agriculture, Co-operation and Animal Husbandry.

Co-ordination. ⟷ Dept. of Industries.

Co-ordination. ⟷ Dept. of Communications and Irrigation.

Public Health Administration.

1. Finance and Pay.
2. Establishments.
3. Personnel (recruitment, transfer and promotion).
4. Supplies; production of drugs and appliances.
5. Survey and Research.
6. Education and Propaganda.
7. Vital Statistics and Records.
8. Legislation.
9. Supervision of the medical profession.

Service: Urban and Rural.

1. Co-ordination with Social Welfare.
2. Social assistance.
3. Environmental sanitation.
4. Communicable diseases control— general and special. Laboratory services.
5. Maternal and child health control.
6. School health control.
7. Nutrition and housing.
8. Physical fitness.
9. Occupational health control.
10. Food and drugs control.
11. Curative Services: Hospital. Dispensary. Domiciliary.

TRAINING.

1. Training of Doctors, curative and Preventive. —University grade. —School grade.
2. Training of assistants.
   (*a*) Sanitary Inspectors. Village Health Assistants. Dentists. Laboratory technicians. Pharmacists. Dressers. Orderlies. Publicity Officers.
   (*b*) Nurses: Public Health and institutional. Midwives. Dais.
   (*c*) Post-graduate and Refresher Courses.

→ Experimental and Community Field Training Centres.

Direction, Supervision and Control.

Provincial Centre.

District Stations.

Sub-divisional Stations.

Thana Stations.

Village Units.

Homes | Environmental | Schools | Places of occupation.

It will be seen that a separate Ministry of Social Affairs, which includes both preventive and curative medicine with the associated Social Services, has been proposed and that the present dichotomy of preventive and curative medicine has been proposed to be abolished, bringing about centralized control under an officer, who may be called the Director of Public Health or Social Affairs. As curative medicine occupies a small portion of modern preventive medicine, it has been proposed to abolish the posts of Inspector-Generals and Surgeon-Generals and to put an officer properly trained in modern public health administration in charge of all the sections. The posts of District Civil Surgeons may be abolished in view of the fact that the District Medical Officer of Health is to function as the Head of the District preventive and curative services.

The District organization, as applicable to Bengal, is shown in the following diagram:—

SCHEME FOR

DISTRICT HEALTH ORGANIZATION IN BENGAL

Population	=	50 millions.
No. of Districts	=	26.
Population of a District	=	1·2 millions.
No. of Sub-divisions	=	72.
Population of a Sub-division	=	500,000 to 700,000.
No. of Thanas	=	600.
Population of a Thana	=	50,000 to 80.000.
No. of Union Boards	=	5,084.
Population of a Union Board	=	5,000 to 10,000.
No. of villages	=	100,000.
Population of a Village	=	250 to 500.

Provincial Headquarters.

District Headquarters.
(= 3–5 Sub-divisions.)
(Base)

Sub-divisional Centre. Sub-divisional Centre.

Sub-divisional Centre.
= 8-9 Thanas.
(Tertiary Centre.)

Thana
(Secondary Centre.)
(= 4-5 Peripheral Units.)

P.U. P.U. P.U. P.U.

Peripheral Units
of 2 Union Boards.
(Primary Centre).

(P.U. = Peripheral Unit.)

In the initial stages, the *peripheral village unit* or *Primary Centre* is proposed to include two Union Boards. Each Primary Centre will be equipped for services of both curative and preventive medicine. It will have a clinic, a dispensary and 5 beds, 3 of which will be meant for emergency aid and two for abnormal midwifery. The staff will consist of a doctor, an Instructor midwife, a compounder and two Health Assistants. The Primary Centre will ordinarily deal with the correction of minor defects and ailments. The beginnings of a domiciliary service may also be attempted here. School health may be looked after, with the voluntary assistance of school teachers. School teachers may also be utilized in vaccination and other types of work, e.g. health education which they can undertake with short training. As regards maternity service, it will be the business of the Instructor midwife to mobilize the indigenous *dais* to train them and to secure their co-operation. In a population of 20,000, 400 confinements are expected to occur annually, of which 10% may be abnormal. One-third of this may be tackled by the trained Instructor midwife. The remaining two-thirds will have to be sent to the next higher Centre (Thana), if expert medical aid is not available locally. The necessary supervision and co-ordination can be exercised from the Secondary or thana unit. The peripheral health centres should be under a single management and should help to co-ordinate all the relevant activities in the territorial zone. They may extend their activities by local branch agencies or by mobile units.

Four to five Primary Centres will constitute a *Secondary or Thana Centre*. The Thana Centre will have a 50-bed hospital, containing 10 beds each for medical, surgical, maternity, pediatrics, and infectious cases. Less than 50 beds in a hospital will increase the overhead cost. There will be a male doctor and a female doctor in charge of the hospital and for the supervision of the Primary Centres. The hospital, apart from attending to such cases as it can manage, will serve as a sorting and diagnostic centre, sending the more difficult and appropriate cases to institutions possessing more elaborate equipment and staff at subdivisional or district centres and to special institutions like tuberculosis hospitals and sanatoria, psychiatric institutions and convalescent homes. If funds permit, a Visiting Public Health Nurse may be stationed here to control the work of Instructor midwives and to train village *dais*. The staff and organization may be augmented as the work increases and as more funds become available.

The Thana units will be connected to the more highly organized *Sub-divisional Centres*. Each Sub-divisional Centre is to have a 100-bed hospital, with 20 beds for each of the sections provided for at the Thana Centre. There will be a male and a female Resident Medical Officer for the hospital and a male or

female officer for the clinic and one or two Public Health Nurses. The public health side of the work will be in charge of a Sub-divisional or Assistant Health Officer who will exercise both executive and supervisory functions. There will be a diagnostic laboratory attached to the hospital. If competent doctors are available at the Sub-divisional town who are prepared to work as Honorary Physicians or Surgeons to the hospital or clinic, their services should be thankfully accepted provided they undergo a short course of training at the Experimental Training Centre, which will be attached to the Sub-divisional Centre. This training centre will be responsible for training midwives, health assistants, compounders and nurses, will develop the methodology of work applicable to the area, and will assess the cost and results of the technique employed. It will also help in stimulating the local authorities and the population to extend the public health activities. This method has been found useful in several European countries and in U.S.A., China, Ceylon and some parts of India (Rockefeller Units). There will be some auxilliary personnel attached to the Sub-divisional Units, such as Sanitary Inspectors and Health Assistants to control epidemics, if and when they occur, and Publicity Assistants to aid in health education. A School Health Officer may be appointed, if funds are available. If not, the voluntary services of teachers may be requisitioned, while exercising supervision and training by technical staff.

The Secondary Health Centres must be equipped in such a way that they are able to supplement the work of the Primary Centres on the technical side and that patients may be moved from one institution to the other as needed. The division of work between these centres will depend mainly on the means of communication available and on whether the population is scattered or concentrated.

The Sub-divisional Centres will be connected with the more highly developed *District Centre.* The District Centre will exercise all the functions of the subsidiary centres but in a more specialized way. They will also supervise the work of the whole District. The District headquarters will have a 250-bed hospital, with 50 beds for each of the different categories of services. Special beds for tuberculosis may be added to this. This hospital will be fitted with all necessary modern equipment and will be staffed by competent officers. Ten to twelve Resident doctors will be needed to run the institution under a whole-time Superintendent. The voluntary services of specialist practitioners in the District headquarters should be utilized as far as possible. The laboratory attached to this hospital will undertake diagnostic, water analysis and food control work. There will be one urban and one rural Demonstration *cum* Training Centre attached to this hospital. This will offer training facilities for Sanitary Inspectors, institutional and public health nurses and

post-graduate and refresher courses for the higher personnel employed in the District. The whole administration will be under a Medical Officer of Health, who will be assisted by specialist officers for the special functions of the District organization. It will be seen that the administrative unit suggested corresponds to the political unit, which fairly corresponds to the distribution and agglomeration of population, marketing and transport arrangements. The suggested scheme is capable of expansion without essentially changing its structure. The first 5 years in this planning may be occupied in organizing curative and preventive services to units of 20,000 people. When more experience is gathered and mistakes are avoided, the Unit may be duplicated or even triplicated.

The District Health Administration constitutes a link between the provincial and local administrations. It should extend to social preventive medicine (health visitors, maternity and child welfare, anti-tuberculosis work, etc.), public health (housing, water supply, sewerage, etc.) and hospitals, carrying out a uniform programme everywhere and aiming at developing the various institutions into a balanced whole. The present isolationist policy of hospitals and dispensaries should be abandoned. In a planned policy, one hospital may deal with say acute diseases, another with chronic diseases, a third with convalescent cases and so on.

The proper training of the medical personnel needed for the proposed framework is a difficult matter. Experience has shown that a minimum annual expenditure of Rs.5 lakhs is needed to run an efficient medical college or school. In the initial stages, it may not be possible to equip such an institution for every district. Efforts should, however, be made to have such an institution in every Division, which usually consists of 5 districts. The supply of medical licentiates to medical graduates in India to-day is in the proportion of 2 : 1. Before the school system of training is abolished, arrangements should be made to provide facilities for the training of the medical and public health personnel, needed for the new organization, at the teaching institutions and field training centres. It would be worth considering whether, after the first 2 years' basic training in the medical colleges, curative and public health physicians' training should bifurcate in order to save time and expense in the initial stages of execution of the scheme, when a sufficient number of qualified personnel may not be available. The position in Bengal is different, as there are already 1,000 doctors employed in rural dispensaries and 2,000 are practising in rural areas. Out of over 11,000 registered doctors in Bengal, only 3,000 are in rural areas.

The Provincial headquarters will provide facilities for the training of the superior personnel and specialized services and will make arrangements for research activities for solving

problems offered by the District and subsidiary units. The training programme should be drawn up with a view to fit it into the eventual whole scheme and the methods devised should first be tried experimentally at selected centres before their general application is advised, in order to avoid wastage of efforts and funds in future. The Provincial health organization should have the help of an Advisory Board, consisting of experts in each line, preferably non-officials, who will study problems and offer such advice as they think fit.

The inspection and control of health work under the local bodies should be left to the Director of Health or Social Affairs. Dual control of work under the Government, local bodies and voluntary organizations of the present time has often resulted in the creation of many administrative difficulties, frequent dislocation of work and serious indiscipline in the ranks and resentment on the part of local bodies. This policy has already been adopted in Madras, Punjab and U.P. and should, therefore, be followed in the rest of India.

The idea is that the curative and preventive services should form a co-ordinated whole, ensuring every rural family a minimum of attention, especially in cases of confinement, infectious disease or accident and in those requiring urgent medical aid. The final goal should, however, be to provide for the whole community the services of doctor, midwife, nurse, specialists and dentists, in addition to laboratory analyses and hospital treatment. The aim should be to prepare a stage-wise and co-ordinated programme 'covering at one and the same time both central and local administrations, both environment of the family and the individual, both preventive and curative action'.

Financial implications of the Provincial scheme (Bengal)

Any scheme in which the overhead charges exceed 30% of the total earmarked budget is financially unsound. Hence, the salaries of the services should be adjusted according to the income per head and taxable capacity of the people.

The close participation of the Rural Reconstruction Department, which aims at co-ordinated uplift of the population by all the branches of the administration, will not only speed up the public health progress but will save a considerable expenditure for social-*cum*-public health progress. Any planning in public health is closely related to the general national planning.

It is understood that the construction of the quarters for the health personnel and of the hospitals and clinics will be undertaken by the local population. It will serve the purposes of national planning, if cheap materials which may last for 20 years or so are utilized in the construction of houses and institutions. Russia was compelled to adopt this for economic reasons in the initial stages of planning. If the methods of

national planning succeed, it may be possible to replace the temporary structures by more permanent materials at a later stage. It is also understood that the local population will voluntarily and actively participate in improving personal hygiene and environmental sanitation.

The recurring annual expenditure of a peripheral or Primary Centre will be Rs.3,000 p.a., that for a Thana Unit Rs.10,000 p.a., that for a Sub-divisional Unit Rs.50,000 p.a. and that for a District Centre Rs.100,000 p.a. This gives us an expenditure of about Rs.2 crores for the rural public health organization in all the districts. To this should be added the cost of central or basal supervision and training centres—Rs.100,000 p.a. Rs.20 lakhs p.a. will be needed for 4 Medical Colleges in the four Divisions of the Province for training the medical and public health personnel. Besides these, a certain amount of capital expenditure (about Rs.5 lakhs) will be needed for equipping the institutions with instruments, appliances and drugs. The development of the Social Assistance machinery is an urgent necessity in the furtherance of public health. The expenditure on this head cannot be visualized at this moment.

Let us see how the expenses can be met. The urban population in Bengal is only 1/16th of the rural population. Yet the per capita expenditure on curative and prevention services in municipal areas is Rs.2-1-9, in comparison with only 4 annas and 4 pies in rural areas. In order to divert more money to rural areas, the Government contribution to municipal areas will have to be starved for some years. Excluding municipal areas, the Government contributes at present (1940-41) Rs.87,83,000, the District Boards Rs.35,38,000 and the Union Boards Rs.14,21,403 or a total of Rs.1,37,42,403 to preventive and curative services. Thus there is a deficit of a like amount in financing the suggested scheme. This can be made available from various sources. One of them is more Government allocation to social welfare services. Out of a total per capita expenditure of Rs.2-7-5 in Bengal, Police expenditure absorbs 8as. and General Administration and Administration of Justice together absorb 8 annas 6 pies per capita or a total of more than a rupee per head, while only 4 annas 6 pies per capita is given for education and 3 annas per capita for preventive and curative health services. Compare this with the per capita expenditure of Rs.35-9-0 for education and Rs.6-9-0 for medical relief and public health in England and Wales. The other inter-related social services in provincial budgets are similarly starved at the expense of a top-heavy and maladjusted administrative machinery.

The scheme which we have ventured to suggest can be made practicable if the cost now being paid by the Government, District Boards and Union Boards is doubled. The present per capita expenditure from these sources is 2 annas 9 pies, 1 anna 1 pie and 6 pies respectively or a total of 4 annas 4 pies.

By doubling the figures, the respective contributions will be 5 annas 6 pies, 2 annas 2 pies and 1 anna or a total of 8 annas 8 pies. The municipal expenditures are left out of account. This is the minimum from where a start can be made. Provided the willing co-operation of the population is secured, enough contributions in kind will be available for the expansion of the scheme.

Bengal Government's recent scheme.

The defects in a skeleton scheme of supplying one Sanitary Inspector, one Health Assistant and one Medicine Carrier to each Thana Unit, numbering 575, introduced in 1927 in Bengal have already been referred to. Recently the Director of Public Health in Bengal has formulated a rural hygiene programme by combining curative and preventive medicine by a Rural Medical Officer, two Health Assistants, a part-time *dai* and a part-time cleaner to 2,500 rural medical units, each comprising two union boards. These are proposed to be linked, for purposes of supervision and control, to Secondary Centres in the sub-divisions under an Assistant Medical Officer of Health, assisted by 2–4 Sanitary Inspectors and office staff. These Secondary Centres are proposed to be linked to the District headquarters under a District Medical Officer of Health. The financial implications of the present organization and the proposed scheme are given below:—

Contributions from.	Per capita expenditure.								
	Present organization.			Proposed scheme.			Total.		
	Rs.	A.	P.	Rs.	A.	P.	Rs.	A.	P.
Government ..	0	2	9	0	0	9½	0	3	6½
District Boards ..	0	1	1	0	0	1	0	1	2
Union Boards ..	0	0	6	0	0	8½	0	1	2½
Municipalities ..	2	1	9	0	0	½	2	1	9½

The additional expenditure needed in this scheme are Rs.22,77,000 from the Government, Rs.2,27,000 from the Distric. Boards, Rs.21,10,000 from the Union Boards and Rs.66,000 from the Municipalities.

It will be seen that, although it marks an advance in the concept of rural health organization in this scheme, the co-ordination and control of the existing curative medical organizations (existing and future hospitals and dispensaries) have been left where it is in the present dichotomous structure, viz. under the Surgeon-General and his subordinates, which goes entirely against the idea of unitary control recommended in all modern public health schemes. This scheme may, however, very well

function as the starting point, provided the principles of public health administration enunciated by us are followed. The scheme seems to be capable of expansion when the necessary personnel is trained, adequate supervision is secured, the methodology developed and funds made available.

SUMMARY AND 'FIRST STEPS'

1. A historical review of the evolution of public health in India and in other countries, particularly England and Wales, has been given. The result of this evolution in Eur-American countries has been that to-day community medical protection has become a field of social activity. The major functions of social life have been mentioned and the fields of social welfare explained.

2. Some principles of sound public health administration have been laid down.

3. The causes of the lag between science and its application in the improvement of public health in India have been indicated and suggestions for their removal have been offered. Emphasis has been laid on the need for a scientific approach, hitherto lacking in India, to modern public health through adherence to the essential principles of public health administration.

4. The essentials for the planning of public health in a province, with special reference to Bengal, are discussed and the working principles defined.

The 'First Steps' in a province, will be for the department of Rural Reconstruction, which should be a co-ordinating department, in every province to set up a Planning Committee, with sub-committees on Social Welfare and other technical fields of rural reconstruction. The 'terms of reference' should be to define clearly the objective, to advise on the best way of developing and demonstrating the methodology of work proposed, to determine how best to apply the same in the wider fields around, to determine the method of training the required personnel and of proper supervision, control and maintenance of their level of efficiency, and to suggest the best means to secure the co-operation and co-ordination of the inter-related departments.

If our suggestions are looked at from a constructive viewpoint, the Rural Reconstruction departments in the various provinces will be expected to move in the matter and to determine what steps are practicable in applying the various principles for efficient and adequate community medical protection in their own territories. I have heard people to say that unless we get complete political and fiscal freedom no progress is possible. I do not subscribe to this view, although I admit that freedom will speed up the progress in every direction. I firmly believe that if we have in us the 'will to live', we are capable of purchasing public health by payments in kind so long as adequate cash is

not available, but for this a national desire to live which is noticeable in other nations, should be present in everybody and voluntary participation must be forthcoming.

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SECTION OF AGRICULTURE

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Presidential Address

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PLANT BREEDING AND GENETICAL WORK IN INDIA

CONTENTS.

I. Introduction.

The President of this section last year made a departure from the usual custom of confining the address to a branch of the subject he was most familiar with, and gave instead an address on a general review of the progress of agriculture. I shall, however, revert to the usual practice. Last year's address had a large portion of it devoted to the value and care of seed. It is probably in the fitness of things that my address deals with the problem of search for, and production of seed with inherent superior characteristics. I shall make a general survey of the plant breeding and genetical work in India and in doing so, refer largely to two crops, rice and cotton, with which I am most familiar.

Scientific breeding with crop plants has become a powerful and indispensable tool for making agriculture more efficient and more flexible in meeting new demands and supplying the needs of men for food and raw material. " In the realm of living things with which agriculture deals, the work of the breeder is comparable to the work of the inventor in the realm of inanimate things with which industry deals, and his work pays in the same way that invention pays by replacing continuously the old by the new or making possible what was not possible before ". The growing of improved types involves no additional expense to the cultivator and the work of breeding improved types has formed an important plank in the activities of the agricultural departments right from the very beginning.

Plant breeding in its strict sense means the production of better crops, the ultimate test of superiority, with exceptions, being greater yield per unit area and hence greater return to the grower. In the case of industrial crops like cotton, besides yield, the. question of quality also comes into consideration in deciding the return per acre and hence breeding for quality does form part of the breeder's objective. At the present time breeding for quality in cotton has become an urgent necessity in several tracts since the bulk of the cotton produced in India is of short staple, the outside market for which has considerably dwindled. Breeding for quality in food crops, cereals, is still not of much importance in our country as the term 'quality' is incapable of a precise definition and usually has no bearing on the nutritive value. To mention only one example, the quality in rice, as is commonly understood, depends upon the size and colour of the grain and upon the extent of polishing it has received. Quality from the nutritional point of view is, however, quite different and if practical effect is to be given to the findings of research work on this problem, (Ramiah *et al.*, 1939) we shall have to radically change our ideas about quality in this most important food crop of the country.

Even in industrial crops, for various reasons beyond the control of the grower, yield under Indian conditions still forms the predominant factor. Let me try to illustrate this with a small example in cotton. The local indigenous cotton grown in Central India is of a poor quality, the lint capable of spinning only 10–12 counts. There is, however, the Upland cotton, which is definitely superior to the indigenous in quality and commands a better price in the local market, but does not yield quite so well as the indigenous as a rain-fed crop. Examination of extensive data on spinning quality and market price for cotton (Panse, 1940c) has brought out the fact that the premium obtained for the superior quality of Upland cotton can compensate only a ten per cent. reduction in yield while field trials have shown that the reduction in yield by substituting indigenous cotton with Upland is much greater than this figure, and hence it is not profitable to grow Upland cotton in Central India on rain-fed land.

II. A Survey of Plant Breeding Results.

i. *Results of plant breeding.*

Scientific plant breeding which is not more than thirty years old in India, has been carried on along the traditional lines of selection, introduction and hybridization. In fact, the methods followed are the same that have been followed in the West and the principles involved, which are fundamental, are applicable to all plants in general. It may be worth while at this stage to take stock of the practical results that have emerged so far from this plant breeding work. The only measure of the success of this work is the total area occupied by the improved types in various parts of the country. Taking India as a whole, the total area under the four important crops and the area devoted to the improved types evolved by the Departments of Agriculture are given below for the year 1937-38.

Crop.	Total area (acres) under the crop, (*thousands*).	Area (acres) devoted to improved strains, (*thousands*).	Percent[age]
Rice	72,277	3,759	5·2
Wheat	35,618	6,930	19·5
Cotton	25,583	5,672	22·2
Sugarcane ..	3,818	2,855	74·8

The area under the improved types of sugarcane is very striking because the superiority of these types over the local, which these have replaced, has been phenomenal. In fact, the

benefit that the country has gained by the results of plant breeding in this one crop, which can be valued in several crores of rupees, has become a classical example of plant breeding achievement, the credit for which goes, in a large measure, to one of our own members and an ex-President of the Congress, Rao Bahadur T. S. Venkataraman. It may be mentioned in this connection that the protection given to this crop has been an important contributory cause for the rapid spread of improved types of sugarcane. That the area under improved types in other crops is not so striking is due to various causes. For one thing, except in the case of cotton and sugarcane, it is so difficult to estimate with any degree of accuracy the area under the improved types, the figures given above, being only rough approximations. Though the percentage area under improved varieties of rice is not considerable taking the country as a whole, it is certainly very much higher in individual provinces like Madras and Bengal where plant breeding has been carried on in this crop for a considerably longer period than in other provinces.

ii. *Spread of improved types.*

Botanists working in the departments of agriculture might produce better types of crops by breeding, but owing to the peculiar conditions in which Indian Agriculture is carried on, small and scattered holdings, the special tenancy systems, financial instability of the grower, the necessity to sell the produce with the seed as in cotton, etc., it is almost impossible for every individual cultivator to multiply his own seed from the improved types and an organization is necessary to make such seed available to the cultivator. The extent of such organization varies in different provinces and States in India. While some provinces like the Punjab spend several lakhs of rupees every year in the multiplication and distribution of seed of improved varieties, there is hardly any expenditure under this item in some other provinces. It must be mentioned here that the amount involved is not a gross expenditure to Government, but only represents a sum invested and later recouped by the sale of the seed. Owing to sudden fluctuations in the market prices, particularly in industrial crops, it is possible there may be a small loss incurred, in certain seasons, but, considering the practical benefit realized, the loss, even if there should be any, can be safely ignored. In the case of cotton, the Indian Central Cotton Committee finances several seed distribution schemes in different provinces and States. Because of the limited funds at the disposal of the Imperial Council of Agricultural Research, they were mainly concerned with financing research schemes and now that the resources of this body are likely to be augmented, it is up to them to see whether they should

not initiate and partly finance seed distribution schemes also in cases where such help should prove necessary and useful.

We cannot unfortunately compare ourselves with countries in the West on this question. There, the multiplication of improved types of crops and making them available to the cultivator is carried out by professional seedsmen as a business. In fact, in some countries like Denmark and Sweden, the seedsmen themselves do the work of breeding superior types. Most of the advanced countries have also Seed Acts in force prohibiting growers from using seed which is not pure and certified. The only non-official organization that might take up this work is special Co-operative Societies and although a certain amount of such work is being done in India, the output forms an infinitesimal proportion of the total requirements.

Any increase in yield which does not come up to ten per cent is rather difficult to be appreciated by the cultivators and in fact, this is the minimum figure aimed at by most plant breeders under ordinary methods of cultivation. In several cases, the improvement claimed by the breeder as a result of extensive trials, is much above this figure. It is generally the experience of plant breeders that improved types respond very much better than the unselected types to more intensive methods of cultivation.

Of the four crops mentioned above, dropping out sugarcane where the area under improved types is very high and has hence markedly increased the output in the country, the question may be raised whether on account of growing improved types in other crops, the output of the country has been perceptibly increased. Persons who do not believe that much benefit has occurred from plant breeding work often compare the standard yields of crops per acre as published in the crop statistics of India with those of other countries to support their case. In the case of rice crop, for instance, the average acre yield in India, which is 825 lbs. in 1937-38, is about one-third to one-fifth of yields obtained in Spain, Italy and Japan. Similarly, the average acre yield of cotton crop in India is, 89 lbs. of lint as compared to 267 lbs. and 531 lbs. respectively in America and Egypt. It is hardly realized, however, that India is a big continent with very divergent climatic conditions and rainfall as compared to countries which register high yields and the total area under the crop in these countries is comparatively small. It will be hardly legitimate to make such a general comparison between countries. So far as can be seen from the published records and from personal knowledge of some important plant breeding centres in the West, the actual increase in *yield* as a result of plant breeding is generally never higher than 20 per cent. This is the figure that has been declared as a workable limit for rice breeding in Japan. If Indian acre yields are still low, the reasons have to be sought elsewhere. India is an old country

and manuring is never practised. The increased yields of strains are masked by the comparatively smaller areas devoted to them. In regions where strains are grown on a larger scale, protected by irrigation and sometimes fertilized, very much larger acre yields are recorded, as for example, Co. 2 cotton tract of Coimbatore and deltaic rice tracts of Madras. In Egypt, cotton yields are high due to irrigation, heavy manuring and silty soils and in America to manuring, virgin soils and protection against erosion. In certain rice areas of Madras where suitable conditions exist, it has been possible to demonstrate that by the growing of improved strains combined with intensive methods of culture, the acre yields can be increased to 3,000–4,000 lbs. per acre, comparable to yields obtained in Japan. I am confident that plant breeding work in India, both from the standard of work and the results achieved, is quite comparable to similar work done in more advanced countries of the West or East.

iii. *Need for improved agricultural statistics.*

In this connection it may be useful to raise the question of the average yields of crops as published in crop statistics. What is the basis of these figures? It is only recently that this question is being examined. Even in the case of cotton where, due to the cotton cess, it is possible to estimate fairly accurately the total output of the country, the figure arrived at by this method differs from the figure given in the statistical reports by over 30 per cent. In the case of other crops, some tests made in isolated centres have shown that the figures vary from those of the statistical reports very considerably. Even the recording of the area under any particular crop has been found to be inaccurate. So far as can be ascertained, the figures of the statistical reports are not of much value. It is a good thing that the Imperial Council of Agricultural Research have taken up the problem of determining standard yields in wheat and rice. A similar investigation is being started for cotton also. Granting that the production is certainly higher than what is stated to be, such increased production should be reflected in a greater well-being of the cultivator, and the question may be asked whether there is any indication to that effect. There is, however, one thing to be mentioned in this connection, namely, that the population of the country has also considerably increased and there are probably other considerations which may be pertinent though beyond the scope of this discussion.

III. METHODS OF BREEDING.

The principles and technique of plant breeding may be briefly described here. Of the three methods mentioned earlier, namely, selection, introduction and hybridization, introduction may probably be left out though there are instances, almost historical, on record, of introduced superior types from one region

to another proving a phenomenal success. Such successes are more an exception than a rule, since it is within the experience of plant breeders that the great range of agricultural and climatic conditions under which a particular crop is grown in different parts of the country has resulted in special local adaptations which naturally limit the scope of such introductions. We can consider the other two methods in greater detail.

i. *Selection in natural population.*

In the tropics, the plant material has not received the intensive study which has been applied to the temperate crops before the ideas of pure lines and Mendelism were brought to bear on the problem. Every crop presents a mixture of types. Sometimes there may be a dominance of one particular type which may amount almost to a condition of purity, but there is enough evidence that such approximation to purity has risen by the suppression of other types by natural agency. The type best adapted to the prevailing conditions survived, but where adaptation for more than one type is sufficiently close, a mixture of types forms the crop. Selection in such material is nothing but exploitation of the naturally existing variability. Have we any methods to say which primary selections in the variable material would give the desired result ? The answer to such a question is, so far as we know, No, and this is the main reason for considering plant breeding as more an art than a science. Intimate familiarity with the crop and the scale on which the selections are made and studied are often the deciding factors in the attainment of success in the method. There is no known method of discriminating the important environmental influence on the crop and the testing of the progenies in replicated and randomized plots is the only criterion to go by. The larger the number of initial selections handled, the greater are the chances of getting a useful type, and for the elimination of undesirable types at the initial stages, the breeder has still to depend upon his visual observations. Although due to the recent advances in statistics as applied to agriculture, designs have been evolved to test even a very large number of initial selections in a replicated experiment, (the incomplete randomized blocks and modifications of the design), still, elimination of a certain number of initial selections without actually bringing them under replicated trials cannot be avoided. Usually the initial yield trials carried out by the plant breeder in smaller plots are later extended to trials in bigger plots under cultivators' conditions in various parts of the tract and the best selection as determined by these series of trials is multiplied and made available for distribution to the cultivators. It has been the experience of the more successful plant breeders that it is not necessary to wait for commencing the district trials until the small scale trials are actually finished, but to

carry on the two trials simultaneously in the later stages. Thanks to the work of the Statisticians, the technique of carrying out the trials has been very much simplified and reduced to a routine. This is in brief the method followed in the selection technique in cereals, rice, wheat, *jowar*, etc. These crops are almost entirely self-fertilized and the initial selection is itself assumed to result in isolating several pure lines and all further work is directed towards determining the best among the several pure lines.

When once pure lines have been established, secondary selection is not usually practised in these crops. It was once tried in rice in Coimbatore to see if there was still genetic variability in one of the established pure lines. Yield was the only criterion that was taken into consideration as there was no morphological variability in the material. Since the variations in yield observed were within the limits of experimental error, it was concluded that it was not worth making secondary selections, in this crop. There are not many records of systematic secondary selection being practised in the cereals and even the few cases mentioned have been carried out more from the point of view of characters other than yield. In cotton on the other hand, secondary selection has always been practised by breeders though, as has been pointed out by Mason (1938), the effect of such secondary selection has been in most cases only of a small advantage while the main improvement has been realized in the primary selection. Such secondary selection has been, until very recently, mainly towards making the selection homozygous, i.e. reducing the genetic variability. In cereals when once a selection is morphologically pure and also reasonably pure for economic characters like duration, height of plant, size of grain, etc., the only point for consideration was yield. In the case of cotton, however, though yield continues to be the main consideration, attention is devoted to two other important characters, namely, length of the fibre and the ginning percentage. These two quantitative characters, to be mentioned again later, are controlled by a number of Mendelian factors and it is impossible to get absolute hymozygosis for these characters even after several generations of selfing. Secondary selection has been mainly directed to reduce the heterozygosity in these two characters to the minimum, and carry forward such of these selections as are apparently pure.

It will be seen from the above that the main principle of selection, namely, exploitation of the naturally existing genetic variability, is not lost sight of in the case of making secondary selection. Hutchinson and Panse (1937*b*) have found out that environmental effects contribute so much to the variability of the breeding material that genetic effects remain undetected by the usual method of progeny row method and have improved the technique enabling comparison to be made

of genetic effects freed from environmental disturbances. The principle of secondary selection is based on the existence of genetical variability, and the attempt of the plant breeder should be to obtain a progressive improvement in his material by the isolation of superior types arising by segregation in the progeny of initially heterozygous selections. The new replicated progeny row technique developed by them helps the breeder to divide the best of his material into two lots, one in which further selection is likely to be profitable, and that which has reached the limit and may be passed on from the breeding to the testing plots. The technique has been used successfully in cotton breeding in Indore and a type with a better quality has been evolved from a strain that was considered under the previously known methods of breeding to be already fixed for that character. In addition to improvements in yield, this technique has also proved highly useful in developing cotton selections showing high field resistance to the fusarium wilt. From material which showed a mean field mortality of 60 per cent. due to wilt, strains have been obtained with less than 10 per cent. mortality.

While the value of this improved technique has been definitely demonstrated in the case of cotton, the question remains whether it would be worth applying it to other crops, particularly, the self-fertilized cereals. An attempt was made to use the method in the selection experiments going on at the Indore Institute on *jowar* and linseed. The data so far available have definitely shown that, while there was no sign of progressive improvement in yield by such secondary selection, genetic variability in lodging of straw in *jowar* and in resistance to wilt in linseed was demonstrated.

ii. *Selection in hybrid population.*

We then come to the question of plant breeding by hybridization. When we find that simple selection is not yielding any material of value, it means that there is no genetic variability to select from, and the only recourse left is to resort to hybridization between varieties so that genetic variability would have been produced to give scope for selection again. Although plant breeders did carry on crossing among varieties even in earlier days, the scientific background for the work was provided by the re-discovery of Mendel's Laws in 1900 and which is now a highly developed science under the name of Genetics. Mendelian principles of heredity are so well known that I need not deal with them here. The science of Genetics has been of great value to the plant breeder in that it has given him a clearer conception of his problems and a better understanding of the processes involved in his work. When Mendelism was first brought to light, great hopes were entertained of combining into one plant various attributes coming from different parents. Whether the practical results obtained in economic plant breeding since the

advent of Mendelism have been commensurate with these hopes, there are differences of opinion. The main aim of economic plant breeding is to get greater yields. Using this as the criterion, it is probably a safe assertion to make that the influence of the science of genetics has been much less profound on the art of plant breeding than was expected by the early geneticists. There is, however, one aspect of the genetical knowledge which has produced profound results. The knowledge that physiological characters like resistance to diseases, cold, etc., are also inherited in the same way as other characters have led to the classical triumphs of Prof. Biffen in producing rust resistant wheats and of Prof. Nilsson-Ehle in producing winter resistant wheats and barleys. Even in India this aspect of plant breeding plays an important part and conspicuous successes have been obtained. We need mention only as examples the wilt resistant *arhar* of Pusa, wilt resistant cotton of Bombay, and blast resistant rice of Madras.

A reference to the annual reports of the provincial and imperial departments of agriculture in India would give an idea of the number of improved types that have been evolved by plant breeding and it is not necessary to give a list of them here. It may, however, be worth mentioning some of the most outstanding ones which are now under cultivation very extensively.

Selections in natural populations:—

Rice	..	GEB. 24 of Madras.
		Indrasail of Bengal.
Wheat	..	Numbers 4 and 12 of Pusa.
		8A of the Punjab.
Cotton	..	Co. 2 of Madras.
		V. 434 of Central Provinces.
		P. 289F of the Punjab.
		Sind Sudhar of Sind.

Selections in hybrid populations:—

Wheat	..	Pusa 52.
		C. 518 and C. 591 of the Punjab.
Cotton	..	1027 A.L.F. and Jayawant of Bombay.
Sugarcane	..	Several Coimbatore types like Co. 213, Co. 281, Co. 290, and Co. 419.

iii. *Mixture or Pure strains.*

The question of the utility of growing a mixture of types rather than a single type may be considered. The idea might appear unscientific to persons accustomed to orthodox views of pure lines, homozygosity, etc. Still it will be evident from what follows that the problem deserves consideration. There has been experimental evidence available with plant breeders to show that a mixture of types grown as such, gives a greater yield than the components of the mixture. Simple

isolations of pure types have no doubt proved an improvement over the local mixtures in several crops like rice, cotton, *jowar*, etc., though it is a general experience with plant breeders that such improved types are of limited value beyond the narrow range of conditions obtaining in small tracts where they were isolated. It is more reasonable to assume perhaps that a mixture of types should prove of greater utility over a wider range of conditions. That certain components of a mixture in spite of their poor performance when grown pure, do manage to maintain themselves in a fairly constant proportion from season to season can only be explained by the advantage they get when grown in competition with other types. The Upland cotton of Central India, when grown as a pure rain-fed crop, suffers badly from diseases and is a poor performer but gains in competition when grown mixed with the indigenous cotton. There have been experiments going on for the last five years with growing these two cottons under different degrees of competition and while the results as regards yields are variable there is a definite indication that the Upland cotton gains by competition effects from the indigenous. There was, however, one consistent result obtained in all the years, namely, that the American in the mixed crop suffered less from leaf-roll and red-leaf than as a pure crop. There was also an indication of the indigenous cotton suffering less from wilt (fusarium) in a mixed crop.

It might be worth mentioning here that there is experimental evidence to show that mixtures do contribute to better spinning quality. For the last two seasons, the material from the experiments with mixtures at Indore has been examined by the Director of the Technological Laboratory, Bombay, and as the figures given below would show, the mixture has a higher spinning value than the average of the two constituents, sometimes even approaching the value of the better of the two constituents.

Spinning values (highest standard Warp Counts).

Mixtures.	1937-38.			1938-39.		
	Actual.	Average of constituents.	Difference.	Actual.	Average of constituents.	Difference.
M9*+M.43-4	22	19·75	+2·25	16·5	17·25	−0·75
M9+V. 434 ..	25	22·50	+2·50	21·0	19·50	+1·50
M9+M.U. 4 ..	20·5	19·0	+1·50	24·0	22·50	+1·50

* M9 .. An arboreum strain evolved at Indore.
M. 43-4 .. Another arboreum strain under study at Indore.
M.U.4 .. An Upland cotton strain under study at Indore.

That fairly consistent results are obtained over two seasons and that similar results have also been obtained at the experimental mill, Egypt, (Hutchinson, 1938*b*) show that the mixtures are in no way a disadvantage from the spinning point of view. Even granting that the growing of mixtures is proved to be more profitable to the cultivator, there are several practical difficulties in giving effect to the findings, but still such difficulties should not preclude the breeder from examining the question.

IV. Development of Genetical Science.

i. *General.*

In the early years of genetics, all attention was concentrated on crossing two types, observing the ratios in which any particular character or characters were appearing in the F_2, and deciding that the character or characters were controlled by a single factor, two factors, complementary factors, duplicate factors, etc. Any inheritance phenomenon of a complicated nature was usually ascribed to multiple factors and laid aside. The results all tended to nothing beyond the confirmation of the universal applicability of original Mendelian laws and their later extensions. The second phase of the development of the science of genetics was the study of the chromosomes and the unassailable evidence produced that they are the carriers of hereditary units or genes. All genetic evidence accumulated so far indicates that the gene offers an efficient mechanism for the evolutionary progress of living organism. Studies on the morphology of chromosomes and the irregularities in their behaviour have been used to determine linkage groups and changes in the inheritance of characters and their linkage relationship. There are some aspects of cytological research which are of great interest and importance to particular breeding problems, as for example, the chromosomal interpretation of species relationship, the conception of polyploidy and the explanation of sterility and peculiar forms of inheritance. Breeding programmes involving wide crosses between species or even genera are based upon the results of cytological research. The use of physical agents like X-rays, radiation, heat, cold, etc., has been brought into play to produce by artificial means changes and disruptions in the composition of chromosomes producing mutations more abundantly and at a quicker rate than what were occurring in nature. More recently alkaloids like colchicine has been used to double the chromosome complement of an organism and thus make a sterile hybrid fertile. The advances in these branches of science, genetics and cytology, have no doubt had their effect on plant breeding. Hudson (1937) in his excellent review has brought together the cases where such advances have been made use of. The

advances in the two branches which had remained entirely distinct through much of their developmental history are all converging to a common synthesis and understanding. One going through the literature on genetics that is appearing in recent times, will be really stunned at the progress that has been made. This progress, however, has not been of help to evolve plant breeding methods, but the plant breeder has still to keep abreast of the advances in genetics and cytology and try to incorporate the precepts in his own work so that he can have a greater control over his material.

In the field of breeding horticultural and vegetatively propagated crops, the value of new genetical and cytological techniques is appreciated and in attacking breeding problems full use is made of the latest advances in those branches. The recent work on potatoes may be mentioned in this connection. The only agricultural crop, where an effective collaboration between geneticists and plant breeders has resulted in results of practical value, is maize in America. It is in the breeding of self-fertilized crops that the value of such advances has not become as apparent as one would wish it to be.

ii. *Genetical work in India.*

The actual position of the work in India in the light of the advances mentioned above may now be considered. Although actual plant breeding has produced tangible results of economic value, probably even more tangible than one would expect from the time and money spent on it, it must be admitted that the latest advances in genetical science have had no appreciable effect on this output. It was mentioned earlier that the first phase of genetical science was the phenomenon of segregation. If we look into the published papers in India within the last 25 years (1910–1935), there have been over 200 publications dealing with the inheritance of characters in crop plants. A large majority of them deal with the simple question of Mendelian ratios. It is only a few that might be considered to go beyond the question of simple ratios. It is known, however, that characters like yield itself and those that contribute to it, as for instance, the number and size of the ear in cereals like rice and wheat, and ginning percentage and lint length in cotton, to mention only a few, are quantitative in their inheritance and controlled by numerous genes each probably having a small effect and impossible to distinguish in the later generations of a cross. Genetical analyses on these characters are hard to follow because of their complex inheritance. Recognition of genotypes which is essential for the usual genetic analysis is generally very difficult as they cannot be separated from environmental fluctuations. Eye judgment in many cases are quite inadequate and simple empirical tests are not always available for isolating

all genetic variants. The inheritance studies on such quantitative characters have therefore not received as much attention as they deserve.

The actual genetical contributions in India are from those who are practical plant breeders, and crop botanists working in the departments of agriculture, provincial and imperial. Their work is circumscribed by the immediate and pressing need of producing an improved strain of a crop, the introduction of which would bring a greater return to the cultivator. The material they set to work upon was the crop grown in the cultivators' fields which was an untouched and richly variable population, and simple selection had given very encouraging results. Almost all the improved strains that have been given out to the cultivators are such simple isolations. By the very nature of the material dealt with, and due to local adaptations, the strains so evolved with rare exceptions, as for example, GEB. 24 rice and Co. 2 cotton of Madras, are necessarily limited in their usefulness to the particular areas in which they were isolated. This naturally led to the decentralization of plant breeding research, which was originally confined to a central station in each province, and a number of small breeding stations one in each of the important tracts of the crop, were opened where the crop of that locality could be studied. This is the experience in provinces where plant breeding work has been going on for a longer time, as could be seen from the number of rice breeding stations in Madras and the number of cotton breeding stations in Bombay and Madras.

The earlier hybridization work that had been undertaken was intended to combine in one individual valuable attributes from one or more types and though the breeders did have a clear idea of what combination they wanted to achieve, the knowledge about the inheritance of the characters, they wanted to combine, was however lacking. Such hybridization programme was more or less a hit and miss method and if any success had been obtained, it was more an accident. The crosses were, however, useful for studying the inheritance of some of the easily distinguishable qualitative characters and most of the publications deal with such inheritance. This is practically the position, at any rate, with some of our most important crops like rice, cotton and wheat. In millets, where selection and genetical studies have been of a more recent date, almost all the publications deal with such Mendelian ratios and breeding for special yield attributes is still in its infancy.

Selection work, whether from a naturally variable material or from hybrid populations, was probably considered a mere routine which anyone with elementary knowledge of genetics could undertake. This might be true to some extent because of the nature of material one is dealing with in a country like India. That still greater achievements in plant breeding have not been

recorded in India, might be attributed to the fact that the nature of the material available to the breeder was not correctly understood and too much emphasis was laid on purity of character, morphological and economical. It is desirable for a plant breeder to have a sound knowledge of the advances in genetics and cytology though he may not yet be in a position to utilize all such knowledge in his every-day work. That more tangible results have been obtained in some provinces than in others might be partly attributed to the fact that breeding work was carried on side by side with genetical studies and also perhaps to better technique employed.

V. Genetics in Relation to Plant Breeding.

i. *Quantitative inheritance.*

The advance in genetics as applied to the quantitative characters and what influence this is likely to have in plant breeding technique is dealt with here. It is true that new conceptions of multiple factors, quantitative inheritance, transgressive segregation, factor combination and inhibition have been invoked, but these have helped but little in practical plant breeding. The study of the inheritance of quantitative characters is intimately associated with applied mathematics and it is this that has practically scared away earlier geneticists and plant breeders from undertaking such studies. The application of statistical methods to living things is known as biometry and has developed into an important branch of biological investigations. Biometry is a necessary mathematical tool for dealing with the inheritance of quantitative characters and no modern geneticist can make much progress without a good grasp of this branch. As was pointed out in an earlier section, the variations on which breeder has to work are of two kinds, environmental and genetic, and it is only when the latter component forms a substantial portion of the total variance, selection can be effective and the problem he has always to face is to reduce the environmental variance to the minimum by suitable technique. In the case of hybrid progenies, the classical method of selfing and selecting from F_2, F_3 and so on, has been the chief method followed and has proved successful in cereals, wheat, rice and also in cotton. As practical examples of successes in this line are rice strains evolved combining yield and strength of straw, yield and resistance to paddy blast, and yield and shorter duration, etc., in Madras. Similarly, the case of strains evolved recently by the cotton specialist, Coimbatore, combining yield and fine and long lint in Cambodia cotton may be mentioned. But such achievements have been brought about not with the definite knowledge of the inheritance of the particular characters whose combinations have formed the end in view. Can the geneticist

suggest more rational methods of what to select and how to select in the hybrid progenies and give information on the genetic variance involved in the different generations starting from the F_2? A beginning has been made at Indore to answer these questions with regard to cotton and I should refer to the work of Dr. V. G. Panse who has just published the first results of this study (1930*a*, 1940*b*). Because of the special statistical methods involved, the work was carried out with the suggestions and guidance of Prof. R. A. Fisher. The quantitative character studied was lint length which is one of the important and at the same time complex character in cotton, in crosses among *G. arboreum* types.

He has shown from theoretical considerations that the genetic portion of the variance in a population can be estimated by growing a set of progenies from individuals belonging to that population and taking the regression of progeny means on parental values. This is an important result, for, as has been stated before, the capacity of a population to show immediate response to selection depends on its genetic variability. The genetic variance in the F_2 population of crosses between C. 520, Malvi and Bani was estimated and is shown below:—

Cross.		Total variance in F_2.	Genetic variance.	Non-genetic variance.
C.520 × Bani	..	3·015	1·543	1·472
C.520 × Malvi	..	3·273	1·576	1·697
Malvi × Bani	..	2·416	0·375	2·041

In the first two crosses, nearly half of the variance is genetic, but in the third cross it is only fifteen per cent. of the total variance. While the bulk of the non-genetic variation would be environmental, the presence of dominance and other interactions between factors would also contribute to it. The effect of non-genetic variability, whatever its source, would be to retard the progress made by selection.

In populations with the same amount of genetic variability the degree of improvement achieved by primary selection will also be the same but the response to secondary and later selections will be determined by the genetic constitution of the character, namely, the magnitude and number of factors involved and their dominance and epistatic relations. With only a small number of factors, the possibility of further improvement by selection will soon be exhausted, whereas with a larger number, selection can be continued profitably much longer. As the variation is continuous and the individual genotypes cannot be recognized, unlike in simple qualitative characters, only a statistical approach is available to study these questions. It does not mean, however, that the estimation of genetical variance and

the number of Mendelian factors involved will straightaway solve the difficulties of the breeder, but if genetics is to play its part in the art of plant breeding such studies are essential.

ii. *Heterosis.*

It is within the experience of every plant breeder that the first generation hybrid is more vigorous than the parents and such vigour disappears gradually in successive generations, and it is to this phenomenon that the term heterosis has been used. We need not go into the theory of heterosis, but it is enough to state that the problem of heterosis is the problem of the inheritance of quantitative characters. The heterosis effect has been demonstrated in crops with regard to several economic characters and the greater the gap in the relationship between the parents crossed, the greater the expression of heterosis. Can the plant breeder make use of the heterosis in his work? In vegetatively reproduced crops like sugarcane and potato, when once the cross has been made, the vigour associated with the hybrid can be maintained almost indefinitely. In cases where hybrid seeds can every time be produced in sufficient quantities to raise a field crop, the phenomenon is of benefit even in crops with sexual reproduction. This has been possible in maize and the advance in maize breeding in U.S.A. is nothing but the exploitation of this principle. Hybrid maize is the most outstanding example of the influence of theoretical scientific research in revolutionizing the production practices of an agricultural crop. The same principle is being applied recently to breeding sugar-beet crop in Sweden. The only grain crop of India in which the breeding principles applied to maize, can be used is *bajra* (*Pennisetum typhoideum*), but no serious breeding work has yet been taken up in this. In breeding self-fertilized crops on the other hand, the expression of heterosis in any considerable magnitude is bound to arrest progress in selection. In the example of the cotton cross discussed in the previous paragraph, the portion shown as non-genetic variance would include the effect of heterosis. It must be stated in this connection, that it is so difficult to analyze the non-genetic variance apart from the fraction due to environmental effect into components due to dominance, heterosis, epistacy, etc., as they are all interrelated to each other.

iii. *Physiological and Genetic Correlations.*

Another aspect of genetics in which more critical research should prove useful to the plant breeder, is with reference to characters that show physiological or genetic correlations. It must be within the experience of every plant breeder that selection for improvement on a particular character results in improvement only up to a point. Beyond that, gains are compensated by depreciation in other characters. There is evidence

of several physiological correlations in crop plants like cotton, rice, and wheat. In developmental studies with cereals like rice and *jowar* in India, the correlation between yield and other characters like size of ear, height of plant, tillers, etc., have been extensively studied and recorded. To discuss a few of these in rice, the height of the plant is very highly correlated to duration (Ramiah, 1933) so that as a general phenomenon, late duration varieties are likely to be taller than short duration ones. Naturally this would set a limitation to obtaining a very short stature type with a long growing period and *vice versa*, though there is likely to be a wide margin for variability in height or duration within the two groups considered separately. Similarly, a correlation is found to exist between yield and duration in the rice crop which may vary anything from 3 to 8 months. Generally under South Indian conditions the best yielders are those that have a medium duration of, say, 5 to 5½ months. Though varieties of shorter duration, 3 to 4 months, are sometimes found to give high yields of 3,000 to 4,000 lbs. of grain per acre under particular conditions of soil and climate, they are generally not so heavy yielding as the later duration types. Varieties of over 6 months in duration, which people are obliged to grow because of certain special conditions in a particular tract, are generally also not very heavy yielders. That this relation is physiological can be seen from the series of experiments that have been conducted with them in Madras (Ramiah, 1937). Since these long-duration varieties are generally season limited, any reduction in age beyond a certain minimum brought about by unseasonal planting reduces their yield potentiality. Now the question is whether a very high yield associated with a variety of, say, 5 months' duration can be combined with an early duration of 3 months. Experience in Madras would appear to show that breeding for such an end in view should prove a waste of time and effort. There was an interesting case in rice where an attempt to combine a packed arrangement of the spikelet on the panicle with a medium size of the grain ended in failure (Ramiah, 1931*b*). The close packed arrangement was always associated with a small grain. The correlation here may be either physiological or simply structural. The case of the cross in rice to combine panicle length and clustering of spikelets may also be mentioned. Combination of length in the panicle with the clustering of the spikelets proved impossible (Ramiah, 1931*b*, l. c.).

There are more chances of the breeder achieving his end, if the character combinations he is after, are genetic rather than physiological. In the case of cotton, within *G. arboreum* species there are types with very high ginning percentage, but with lint of very poor quality, and types with poor ginning but with finer and longer fibre. The cotton breeder would like to combine these two characters as high ginning and longer fibre both contribute to a better price being obtained by the cultivator

for his produce. Though critical evidence is lacking, it may be stated from the results of breeding data available, that it is not possible to combine the two characters beyond a certain limit. To get critical data bearing on the point, an experiment has been going on for the last three years in Indore which may be referred to here. In the F_2 population of the crosses between C. 520, Malvi and Bani, plants with the highest and lowest values of ginning percentage and with the highest and lowest values of lint length were selected and F_3 progenies grown from these. The correlation coefficients between the mean values of the progenies for ginning percentages and lint length are:—

C. 520 × Bani	..	−0·254
C. 520 × Malvi	..	−0·425
Bani × Malvi	..	−0·286

All the three coefficients are negative but insignificant. The combined correlation coefficient is −0·324, which just falls short of significance on the 5 per cent level. This small negative relation between ginning percentage and lint length is reflected in progenies selected for high ginning percentages having a slightly lower lint length than those selected for low ginning. It is probable that this negative association is genetic rather than physiological, because no such consistent relationship is observed between the ginning percentage and lint length of the individual parental plants of these progenies. The fact that the processes of lengthening and thickening of the cotton fibre do not take place simultaneously also supports the conclusion that the relationship is not likely to be physiological.

Cases of several correlations between morphological and quantitative characters have been recorded in cotton and rice and to have an idea of the scope of such correlations the following few may be mentioned here :—

Cotton :—between corolla colour and lint length; between corolla colour and lint index (Hutchinson, 1931); between red plant body and length of vegetative period (Leake, 1914), and lint colour and lint length (Kottur, 1923).

Rice :—between sterility and growing period (Ramiah, 1931*a*); between anthocyanin pigment and yield (Ramiah, 1933 l. c.); between anthocyanin pigment and tillering (Ramiah, 1935) and between colour of grain and weight of grain (Parnell *et al.*, 1922).

Such studies in other crops should prove very useful to the plant breeder.

iv. *Use of 'Discriminant function'.*

In very recent times the question of the use of 'discriminant function', first suggested by R. A. Fisher (1937) in plant breeding

has been brought in. The only paper we have relating to the subject is that of Fairfield Smith (1937) which relates to wheat and he comes to the conclusion that with a number of lines derived from a 'composite hybrid mixture', initial field selection for yield might be made on the basis of the size of the grain. In simple language the principle may be explained as below. In every crop the yield could be divided into a whole set of different features as for example, the number of ears, the number of grains per ear and the weight of the individual grain in cereals like rice and wheat. The analysis of yield might show that certain of these attributes are more variable due to environmental conditions than others, and in basing selections for yield, more weight should be given to such an attribute that shows less variability due to environment. The principle is perhaps not new as the developmental studies initiated by Prof. Engledow in Cambridge did take into consideration the yield attributes in making selections, but no systematic experiment has been made on the points. In rice breeding also such attributes of yield as tillering, ear size and grain size have been used successfully. A necessary requirement for the use of a discriminant function is experimental data to determine what measurements are least affected by environmental fluctuation. In cotton for instance, there are several characters which are components of yield such as bolls per plant, seed cotton per boll, seeds per boll and lint per seed. Though from experience it may be stated that some of the above attributes like bolls per plant were much more variable than others, an attempt is being made in Indore to get experimental data to see how far we can use the 'discriminant function' in cotton breeding.

v. *Wide Crosses.*

The problem of the wide crosses and study of the range of variability in crop varieties may be considered at this stage. This has come to the forefront because of the work of Vavilov and other Russian botanists and because of the great advance made recently in the study of polyploidy. One often hears of the necessity to have a wide collection of types for use in breeding. So far as India is concerned, the point has got its possibilities as well as its limitations. For instance in cotton, India being itself the home of one of the most important species *G. arboreum*, with several secondary centres of origin (Hutchinson and Ghose, 1937*a*), there is nothing probably to be gained by bringing in new collections from outside so far as this species is concerned. But the demand for producing better quality cottons in India is sometimes considered capable of solution by the increase in the cultivation of Cambodia or Upland cotton (Ramanathan, 1938). All the types of this cotton that are now being grown extensively are the relics or acclimatized types of Upland Americans introduced from America in earlier years. Selection

from the introduced types of America has not been very fruitful. No material from the original source with plenty of genetic variability has been tried and it is possible that in its original home types may be available that may prove suitable to tracts in India which do not grow this cotton now. It is from this point of view that an extensive collection of material from the original source might prove of interest. Similarly, intensive attempts by breeders to improve *G. herbaceum* cottons of India have led to the same inference that material from outside India should be introduced (Ramanathan, 1936).

With regard to rice, there is plenty of variability to be found in the various parts of India and there appears to be no justification for introducing variable material from outside. There are still several unexplored regions within India itself and work in Coimbatore has shown that such exploration is bound to give the breeders new species, still undetermined, which may be useful to them. The importance of wide crosses particularly with wild types is receiving increasing attention and the results of such work elsewhere and in India too have been useful in introducing into the cultivated types, characters such as hardiness and resistance to diseases which are usually present in wild forms. From this point of view, collection of wild types is certainly desirable and it has proved of practical importance in sugarcane already. Similar results are expected in potato also. Exploration of wild types particularly in the improvement of fruit has not received any attention it deserves in India, though North East India is known to be the original home of certain citrus types.

Though there has not been much of genetical work as related to wide crosses in India itself, workers in India have not failed to make use of the knowledge accumulated elsewhere in attempting wide crosses. More from the scientific point of view, some years ago a programme of crosses between different species of rice was undertaken in Coimbatore. Some of them had proved of cytological interest and in throwing light on the phylogeny of rice (Ramanujam, 1938), (Parthasarathy, 1939). It is interesting to note that the progenies of one interspecies cross *O. sativa* × *O. longistaminata* has given some material of economic value. In one of the papers contributed to the agricultural section of this year (Sreenivasan *et al.*, 1941) is recorded the obtaining of drought resistant strains from the above cross. It is quite likely other interspecies crosses might also give useful breeding material.

Regarding interspecies crosses in cotton though crosses within the Asiatic species and within the New World species are practicable and have been extensively tried, there is no record to show of any valuable material having been obtained from such crosses. Harland's work (1932) has shown that crosses can be effected between the two Asiatic species and between the

two New World species, but homologous characters are built up in such widely different ways in them that the genetic balance is usually disintegrated by segregation in F_2 and later generations. He has, however, shown (1936) that it was possible to transfer single genes or small groups of genes from one species to the complement of the other, but not breeding of intermediate types. This is achieved by the technique of repeated back crossing and one of the recent cases where a success has been reported (Knight and Clouston, 1939), is a cross between *G. hirsutum* × *G. barbadense* where the resistance to 'blackarm' in one of the strains of the former has been transferred to a type of the latter using the above technique. The crosses between the Asiatic and American species are still wider since they involve differences in chromosome number as well. But even such wider crosses have not scared away plant breeders and have been made in Russia and recently in India as well (Amin, 1940). The knowledge about the use of colchicine in doubling chromosomes has encouraged these attempts and since the work is still in an experimental stage, nothing can be stated definitely about its economic possibilities.

In fact, the lead in the attempt at wide crosses has come from India particularly in sugarcane, due to the enterprise of Rao Bahadur Venkatraman. He has succeeded in making such wide crosses as between sugarcane and sorghum and more recently even between sugarcane and bamboo. The latter work, though still in its infancy, appears to show enormous possibilities of improving the sugarcane crop. It must be remembered, however, that sugarcane is a vegetatively propagated crop and the difficulties of further selection are absent.

In rice where all the cultivated forms are grouped under one single species with the same chromosome number, there are geographical races which differ in their chromosome make up. Crosses among such races are possible and have been repeatedly made in spite of initial difficulties in several cases, but still there is no record of any considerable practical success having been obtained by such crosses anywhere. The case is, however, different in cotton where different races of *G. arboreum* and *G. herbaceum* exist with the same chromosome numbers and hybridization among them within the species has given results of practical value.

vi. *Limitations in wide crosses.*

With our present assumption of a large number of genes controlling quantitative characters, one should expect to get all possible combinations of characters in the F_2 and later generations provided, a sufficiently big population is grown of them. Recent work by E. Anderson (1939*a* and *b*) on the point is very illuminating. He has shown by experimental data in a species cross in tobacco that, however manifold the recombinations might

seem, they are in reality but a small proportion of the possible recombinations of the parental species. He discusses the powerful restrictions to character recombination in F_2 under four heads: gametic elimination, zygotic elimination, pleiotropy and linkage. Every plant breeder must be quite familiar with gametic and zygotic eliminations in crosses between species or races which manifest themselves by pollen sterility and non-viability of seed produced. The question of pleiotropy where a single primary effect of a gene results in manifold effects on the development of the plant has not received as much attention as it probably deserves. Recently we have been studying in Indore the pleiotropic effects of one of the genes that is responsible for lintlessness in cotton. The homozygous lintless type is a much shorter plant with suppressed internodes, somewhat late in maturity and with a definitely different growth rate as compared to the linted type. The lintless type has also shown variations in its survival according to the environmental conditions. The large number of genes controlling quantitative characters located in the various chromosomes should, as shown by Anderson, be closely linked because of the restricted number of crossovers possible in the chromosome. It is definitely proved that in spite of the variations from plant to plant in the hybrids as a group, the characters of the parental species or races tend very strongly to stay together. The above findings have an important bearing on plant improvement. In this connection mention might be made of a serious effort made in Coimbatore over a series of years to obtain a valuable combination of characters found in different races of rice. One of the types originally imported from Java had a special characteristic of very long ears, about twice the length of any to be found in the local types but the length was compensated in this variety by extremely poor tillering, i.e. fewer heads per plant. The attempt made was to combine the ear length of this variety with a greater number of smaller ears in another standard strain. The cross was carried on up to F_9 and F_{10} selecting from each generation in the usual way and ultimately when the final selections were compared against the local strain, they failed to approach the yield of the latter. It is known that tillering and ear length must be controlled by several factors and the failure of the attempt to synthesize this desirable combination only shows that such a combination, high ear number of one parent with the length of the ear of the other parent did not occur in the cross. We should probably have been content in this cross with an intermediate tillering and intermediate size of ear. As Anderson has pointed out the most efficient way of achieving the desirable combination would have been to make crosses among selections which are most like one of the parents in ear length with those which are most like the other parent in ear number. In this connection another interesting cross in rice which has been

attempted in the United Provinces might be mentioned (Sethi *et al.*, 1937). The problem of rice fly infestation is important in this tract and trials are being made to get over the difficulty by producing types with enclosed earheads by crossing the ordinary type with another *sathi* type, where the earhead remains enclosed inside the leaf-sheath (cleistogamous). The *sathi* rice is a very poor yielder and has a coarser grain, but cultivators grow it for this one character of its escaping the attack of ear fly. The cross has been carried up to F_8 or F_9 generation and types with enclosed ears have been obtained which are an improvement over the *sathi* rice, but not comparable to the normal type in yield. The inheritance of the enclosed ear type has been studied and found to be of the multiple factor type and it is quite possible greater progress might be achieved by crossings among selected types, those *approaching* the *sathi* parent in ear character and those *approaching* the normal type in yield from the hybrid generations. This is probably a definite case where advances in genetical knowledge could be put to practical test in economic plant breeding.

VI. Maintenance of Purity of Strains.

The question of the deterioration of strains once fixed and released for distribution to the cultivators might be considered. It is a usual complaint from cultivators that a strain, though known to give a good performance to begin with, deteriorates after a period of time. Such deterioration where it is proved to exist may be either due to non-genetic or genetic causes. In spite of the fact that sugarcane is a vegetatively propagated crop, the deterioration of the Coimbatore types intensively cultivated in the United Provinces can, from the data available so far, be shown to be due to greater incidence of pests and diseases because of the faulty agricultural practices, namely, the growing of the crop repeatedly without sufficient rotation in exhausted soils. In the case of self-fertilized cereals like rice and wheat, so far as simple (selections) pure lines distributed by the Departments are concerned, there is no evidence of such deterioration. Once, seed of a strain of rice (GEB. 24) in Madras was obtained from the district where it had been distributed four years previously and in an experiment at the central station no sign of deterioration could be found. It must be pointed out, however, that the seed was to all practical purposes as pure as the seed of the experimental station itself. A similar result was obtained in Coimbatore with regard to Co. 2 cotton strain (Ramanathan, 1937). Dr. Shaw (1935) mentions a case where one of the Pusa strains of wheat had been declared to have deteriorated, but he found the seed obtained from the locality to have been badly mixed up with other types. Fairfield Smith (1938) has mentioned a case in America where

some of the wheat strains from Turkey Red Wheat which were very much better than the control to begin with ultimately came down to the level of the control after some years. While deterioration due to the strain getting mixed up with other inferior strains in the course of cultivation by growers is beyond the scope of the breeder's work, deterioration due to genetical causes comes within the breeder's purview. In the case of cotton when once a strain has been released for distribution, the only thing we know is that the genetic variance has been reduced to such an extent as not to be detected by ordinary methods of plant breeding, but there can still be sufficient genetic variability left in the material which can exhibit itself in course of time. Though experimental proof is not available, it is possible that in quantitative characters controlled by a very large number of genes, there may be small mutations (East, 1935) and such mutations can result in deterioration. If the residual genetical variability left in the strain is such that the strain consists of genotypes some slightly better than others, deterioration can result by the gradual increase of the poorer ones. By the adoption of a small replicated progeny row test at the breeding station every year, we can weed out poorer genotypes from the material. Such deterioration due to genetic causes is known to exist even in self-fertilized cereals where the strains are from hybrids. Such strains are known to throw 'off-types' after some generations (Engledow, 1933) and the gradual deterioration in this case might be attributed to a residuum of impurity and the decreasing percentage of heterozygosity from generation to generation. In progenies of wide crosses such 'off-types' might occur due to cytological causes, losses in chromosome segments or even whole chromosomes (Love, 1939). It follows therefore that a well-organized scheme of seed multiplication and distribution must be continuously kept up. A nucleus must always be maintained at the breeding station to form the primary source for multiplication. The Cotton Committee have recognized this principle and are actually financing schemes for maintaining nucleus of cotton strains evolved at the breeding stations.

VII. Organization of Genetical Research.

In the preceding pages a brief outline of the plant breeding and genetical work in India has been given and indications made in what aspects the advances in genetical science can influence plant breeding practices. Plant breeding as has been pointed out already has a definite utilitarian end in view, namely, that the cultivator must get something more than what he gets now by growing the new variety put out by the plant breeder. This is, in fact, the touchstone for the ultimate success or failure of any plant breeding programme. The attempt

of the breeder to find something better than the existing one is, from its very nature, a never-ending scheme and hence the research has to go on continuously. Unlike other aspects of agricultural research, plant breeding work is capable of giving returns, several times that of what is actually spent on it and there is also the additional advantage of the results of plant breeding research being taken up readily by the cultivator as it involves no additional expenditure on his part.

Though the advances in genetical science have come mainly from the work in organisms of no economical value like *Drosophila*, *Oenothera*, *Datura*, etc., so far as India is concerned, the little genetical work that has been done is all related to agricultural crops. A great deal of genetical work even in these crops yet remains to be done. While part of it may be of practical value, it may include also other aspects which would simply add to our knowledge of these crop plants. The latter might be called basic research in genetics, and there must be some organization to carry on this work. The crop botanists of the provincial departments of agriculture have always got the pressing problem of producing improved types by ordinary breeding to replace existing types of crops and all of them cannot undertake problems of basic research either for want of time or want of facilities. Autonomous bodies created for individual crops like the Indian Central Cotton Committee for cotton have recognized the importance of such basic research. This body is financing a genetics research scheme in cotton. This basic research carried on at Indore is concerned mainly with one aspect, namely, research that has a direct bearing on plant breeding technique. The Jute Committee which has recently come into existence is expected to do for jute what the Cotton Committee is doing for cotton. The imperial department of agriculture formerly at Pusa and now in Delhi is doing a considerable amount of plant breeding work of practical value and also a certain amount of basic research on genetics of crops. The Imperial Council of Agricultural Research is the other body created as a result of the recommendations of the Royal Commission on agriculture that can arrange to see that such basic research in crops is carried on. The finances available with this body have been rather limited previously, but due to the passing of the Agricultural Produce Cess Bill recently, there is likely to be considerable improvement in the near future. This body has spent during the last 10 years (1929-30 to 1938-39) a sum of about 25 lakhs of rupees on crops generally, including all aspects of research besides another sum of about 16·5 lakhs on sugarcane alone. Of the former amount, nearly 50 per cent. has been devoted to financing schemes of rice research in provinces. This amount spent by the Imperial Council of Agricultural Research on crop research is in addition to what the provinces and States are

spending from their own budgets. It will still be worth mentioning that what is spent on this research in India, considering the size of the country, variety of crops and problems, will not compare favourably with what is spent on similar work in countries like Japan and Egypt. Towards plant breeding and genetical research, the former spends about 28 lakhs of rupees and the latter 5 lakhs of rupees annually. Looking into the nature of the schemes financed by the Imperial Council of Agricultural Research with regard to crops, with the exception of a few which can be termed basic research, the majority of them are of a routine nature, ordinary plant breeding schemes. Some of them are schemes either on new crops, for example, fruits, where no systematic work had been done previously or on crops which certain provincial departments of agriculture had not done any work on previously in spite of their importance to them. With regard to rice, a certain amount of basic research has been done under the schemes, but the bulk of them have dealt only with problems of local interest, namely, evolving improved strains out of local varieties in the provinces. Even the programmes of basic research, I am referring only to genetics here, have not generally been on any preconceived and co-ordinated plan. There is no doubt that with greater co-ordination, more valuable results might be achieved. One example of what a good co-ordinated scheme of basic research can be, might be mentioned from America. Maize (corn) is the most important cereal of the country, perhaps not more important than rice to India, and every University or State Agricultural College is doing some work on the crop. In 1928, Corn geneticists initiated a systematic study in which each of the 10 chromosomes of Corn was assigned to workers in different institutions. This co-ordination of effort has eliminated much duplication and has speeded up the research programme to a remarkable extent. The inheritance of over 350 genes has been studied and their position in individual chromosomes has been determined.

Due to the initiative of the Imperial Council of Agricultural Research, methods of describing crop plants from the genetical point of view have been standardized with regard to the two crops, cotton and rice (Hutchinson and Ramiah, 1938*b*), and similar work is in progress with regard to other crops also. When the available material has been actually described according to the methods prescribed, it should go a long way in helping the breeder to understand the material available with his colleagues in other parts of India.

When the problem of plant breeding work in India was discussed before the Crops and Soils Wing of the Board of Agriculture in December, 1937, it was considered that plant breeding research may have to be carried on at several centres particularly in crops with limited adaptibility, examples rice and cotton, but that basic research should be confined to one or

two selected centres only. Involved with the question of basic research is the question of crop introduction. The question of the formation of the Bureau of Plant Introduction under the auspices of the Imperial Council of Agricultural Research had already been discussed at two meetings of the Board of Agriculture, 1935 and 1937, and the principle has been accepted. Now that the finances of the Imperial Council of Agricultural Research are likely to be augmented, the question of the starting of an organization on the model of the Bureau of Plant Industry in United States of America might be considered. This bureau in America which works with headquarters at Washington has got on its staff a large number of eminent men on the different branches of crop research, and such men not only co-ordinate the various items of research in the different States, but also place at the disposal of workers or bring to the notice of workers of achievements in their branches recorded elsewhere. The Bureau is also in charge of the introduction of crops and plants into the country and arrange for their tests in suitable centres in co-operation with individual States. The Bureau also undertakes, whenever necessary, to send individuals and expeditions to various parts of the world to collect material of value for breeding purposes. Will it be too much to expect that a beginning on this model will be made in India ?

While the advances in the science of genetics have been dealt with chiefly with reference to crops, the principles are of equal application to animals as well. The principles of genetics have hardly been utilized in the breeding of stock in India and I do not know whether genetics is ever taught to the students of the Veterinary Colleges. There is still another aspect of genetical science as applied to human race. The science of biometry in its application to genetics has been responsible for all our present-day knowledge on human inheritance (Eugenics). I am not sure that sufficient attention is paid to the teaching of eugenics to the students in any of our several medical colleges in India. A rough idea of the development of genetical science along diverse lines can be had from the papers that were contributed to the Seventh International Congress of Genetics held in Edinburgh in 1939. There were 353 contributions grouped as below:—

Gene and Chromosome theory and Cytology ..	61
Physiological genetics	46
Animal breeding in the light of genetics ..	53
Plant breeding in the light of genetics ..	46
Human genetics	51
Genetics in relation to Evolution and Systematics..	52
Statistical genetics	17
Genetical aspects of growth—normal and abnormal	27
TOTAL ..	353

VIII. Genetical Work and Universities.

Before I conclude I should like to say a few words about our Universities. There are seventeen Universities in India, almost all of them having affiliated colleges teaching up to Honours degree in biology but not one can still boast of a chair in genetics. The Honours students in Botany do, I believe, receive a few lectures on principles of Mendelism, but whether they get anything beyond that is very doubtful. Recent advances in genetics have had a profound effect on our knowledge of taxonomy and ecology, but still it is doubtful if students are made to get a grasp of such principles in their taxonomic studies, which, so far as I know, still form a big portion of the botany syllabuses in the colleges. It is a point worth considering whether the taxonomical syllabus should not be cut down a little and the same substituted by genetical studies on agricultural crops. Even in connection with the taxonomical studies in the Universities, botanical excursions to key regions of agricultural crops and plants in co-operation with the crop botanists could be usefully undertaken. There is a wide field for this work in India particularly with our important crops, rice, sugarcane, fruit trees, etc.

There is one branch of botanical research in which several Universities have got competent Professors to undertake and guide research. I am referring to cytological research. From what has been said in the earlier portions of this address, it will be evident that most of the latest advances in genetics have come from cytological research. Still most of the cytological work done in India refers either to the embryosac development in some unimportant plant or determination of chromosome numbers. The plant breeders in the course of their work come across various problems necessitating intensive cytological studies which can easily be undertaken in the Universities. In some cases where crop botanists are making fundamental studies on their crop, they have their own cytological sections, but still I feel that this is a branch of botanical research in which the agricultural departments and the Universities can well co-operate in the interest of maximum output in the country. In recent times there have been a large number of brilliant young men who have gone abroad for intensive cytological studies and returned to India. Surely it should be possible to make use of these men in this work. Even in other branches of botanical research, physiological genetics, for example, such a co-operation between crop botanists and Universities should prove extremely beneficial. I am mentioning the above points not with an idea of criticizing the botanical work in the Universities, but to draw attention to the necessity for a change in the outlook. I am sure the difficulties, if there should be any, against such co-operative work, could be got over by personal contacts of individuals interested in

common problems. The Imperial Council of Agricultural Research, when it was first formed, did have as one of its objects, bringing about a greater co-ordination between agricultural departments and Universities and it has succeeded to some extent in the attempt. Two instances of such successful co-ordination may be mentioned in this connection, namely, the rust work in wheat, and the general statistical work as applied to agricultural experiments. Let us only hope that such healthy contacts between workers in the agricultural departments and the Universities will be brought into effect in an ever-increasing measure, resulting in a greater output of basic research in the country.

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SECTION OF PHYSIOLOGY

President :- B. B. DIKSHIT, PH.D., M.R.C.P., M.B.B.S., D.P.H.

Presidential Address

(*Delivered on Jan. 4, 1941*)

SOME OBSERVATIONS ON SLEEP

I must first thank the Indian Science Congress Association for inviting me to be the President of the Physiology Section this year. It is usual on occasions like this, especially for one whose official designation is a 'Pharmacologist', to say that the invitation was accepted with a good deal of diffidence and hesitation. I had no such hesitation in accepting this honour because I do not think there is any difference between a pharmacologist and a physiologist. Sir Henry Dale, Prof. Otto Loewi, Prof. C. F. Heymans are often designated as pharmacologists and yet they won the Nobel Prize for work in experimental physiology. Profs. A. J. Clark, J. H. Burn, J. H. Gaddum and E. B. Verney are some of Great Britain's distinguished physiologists though all of them occupy Chairs in Pharmacology. Here in India one of my distinguished predecessors, Col. R. N. Chopra, has also been officially designated as a pharmacologist and yet he has contributed more to experimental physiology in this country than any other single individual.

I did, however, hesitate to accept the honour because my own contribution to experimental physiology is limited. Moreover, I have chosen for this address a subject which has its basis on this limited experimental work. I was encouraged to do so by the remarks of our distinguished President of last year, Prof. Birbal Sahni. In the very beginning of his presidential address Prof. Sahni says: 'When a man of science accepts the position of honour in which I find myself this evening it is usually understood that he undertakes, among other things, to engage a large public audience, having the most varied pursuits in life, on some topic of general scientific interest. *At the same time he is expected to have at least something to say that he can claim as his own and, what is more, to say it in plain language.*' I hope that what I am going to say to-day will interest a sufficient number of young physiologists who have assembled here to induce them to pursue these investigations further.

The subject of this address is 'Some Observations on Sleep'. In spite of the immense strides that experimental physiology

has made during recent years, it must be admitted that the problem of sleep remains to this day unsolved. The phenomenon of sleep has, however, been investigated by a very large number of workers from various points of view. Observations on the physiology of sleep have been numerous. Almost every organ of the body has been studied and its relative behaviour in sleep and waking state compared. I do not propose to discuss here the various aspects of sleep that have been studied, important though they are, because such an attempt will require several hours. Most of the literature on sleep is in German, some in French, comparatively little in English. A complete review of the literature before 1913 is given by Pieron in his work 'Problem du Sommeil' and most of the literature in the next fifteen years has been admirably summarized by Kleitman in his monograph on 'Sleep' published in the Physiological Reviews. A very important contribution to the various aspects of the problem of sleep has been made by Viennese School of Scientists in their publication 'Der Schlaf' edited by Sarason. I shall, therefore, refer to the literature only on those points which concern us directly in our discourse this morning.

Physiological changes during sleep

I shall begin by making a few observations on the physiological changes that occur during sleep. I propose to refer to only four points, viz., circulation, respiration, muscular movements and sweat secretion.

(*a*) *Circulation:*

A number of observations have been made on the heart rate and blood pressure during sleep and the generally accepted view seems to be that the rate of the heart and the level of blood pressure are lowered during sleep. Brooks and Carrol (1912) for example observed 127 patients and found that in most of them there was a fall in blood pressure attaining the lowest level 1 or 2 hours after the onset of sleep. It is interesting to note that their patients who were 'resting' but not 'sleeping' did not show the same degree of fall. Similar results were obtained by Mueller (1921), Mac William (1923), Shepard (1914), Landis (1925), and others. A reduction in the rate of the heart has also been observed by several workers. Klewitz (1913) found a reduction of 14·8 beats per minute in the rate of the heart during sleep while Kanner (1926) found it to be 13·2. Lowering of the pulse rate has been observed by other workers also (Weichmann and Bamberger, 1924; Mac William, 1923; Boas and Weiss, 1929). It must be stated, however, that such reduction in heart rate and level of blood pressure cannot be found if sleep is disturbed as for example by dreams.

Although there is a general agreement that the blood pressure falls during sleep, there is no evidence to show that this fall

causes sleep by producing cerebral anaemia. Howell (1897) was one of the early supporters of the cerebral anaemia theory of sleep. Shepard (1914), however, made very carefully controlled observations on patients with trephine holes in the skull and came to the conclusion that there was a significant rise in the brain volume, indicating an increased blood supply to the brain. Kleitman (1928) made direct observations on puppies and failed to observe any evidence of cerebral anaemia. Mac William (1923) expressed doubts about the validity of the cerebral anaemia theory and thought that the slight lowering of blood pressure will be more than compensated for by the change of position from the erect to the horizontal. Recently Gibbs, Gibbs and Lennox (1935) obtained direct records of cerebral blood flow during sleep in man by means of a thermo-electric blood flow recorder and concluded that the onset and termination of sleep did not affect the blood flow through the brain. Therefore, as Landis (1925) observed the fall in blood pressure is rather a resultant of, than causative of, sleep.

(*b*) *Respiration :*

Many observations have been made on the rate and rhythm of respiration and most of the observers agree that respiration is depressed during sleep. Pieron as early as 1913 observed the depression of respiration during sleep. Bass and Herr (1922) found an increase in the CO_2 tension of the alveolar air during sleep, and Hess (1932) thought that the changes in the CO_2 concentration of blood found during sleep would substantially activate the respiratory mechanism in wakefulness, showing an active depression of the respitatory mechanism. Wright (1931) observed that the respiratory mechanism was definitely depressed during sleep and breathing became inadequate to the needs of the body.

Certain changes have been observed in the type of respiration when a person falls asleep. Cheyne-Stokes breathing was observed by Broadbent (1877). Mosso (1878) thought that the breathing became more thoracic and less abdominal. Shepard (1914) supported Mosso's observation while Reed and Kleitman (1926) failed to find any such change. Some of the changes in the type of respiration could be accounted for by changes in position from the erect to the horizontal, but changes in the chemistry of blood evoking no response from the respiratory mechanism is undoubtedly due to the depression of respiratory centres. Kunze (1928) reported an increase of 10% in blood acidity and this increase will certainly stimulate respiration unless the centres are actively depressed.

(*c*) *Muscular Activity :*

One of the important concomitants of sleep is a complete muscular relaxation and lessening of the voluntary muscular

movements. Muscular movements during sleep have been studied a good deal by some simple mechanical device applied to the bed of a subject or a cage of an animal and a record of movements graphically registered. Szymanski (1918, 1920, 1922) obtained a number of such 'actograms' and by recording the activity of different animals divided them into two classes 'polyphasic' and 'monophasic'. According to Szymanski the polyphasic animals have a number of alternating periods of rest and activity during 24 hours. White rats, for example, have ten. They rest for a couple of hours, then wake up and are active and again fall asleep. Rabbits have about sixteen periods of rest and activity during 24 hours. Birds are generally monophasic, active during the day and resting by night. Adult human beings are monophasic but a new-born baby is, like a rabbit, typically polyphasic. It is generally known that the muscles are relatively toneless during sleep, the tendon reflexes are diminished and the plantar reflex may be extensor.

(*d*) *Sweat Secretion:*

References in the literature about the secretion of sweat during sleep are not many. Potzl (1929) mentions that sweat secretion is increased during sleep and quotes Czerny when he says that 'the sweat drops in a sleeping child can be easily seen'. A more detailed study of secretion of sweat in children was recently made by Day (1939). He studied insensible perspiration by the method of weighing hospital children at frequent intervals and found that insensible perspiration was considerably increased and with room temperature about 29°C. visible perspiration was nearly always present at the onset of sleep. Day's studies show a close relation between the onset of perspiration and commencement of sleep.

In this country with the usual warm atmosphere it is a frequent experience to see sweating especially immediately after the onset of sleep. Beads of perspiration are seen over the forehead and neck and many times the whole body is covered with palpable if not visible perspiration. This phenomenon is more commonly observed in children but is present in adults also. It is important to note that the sweating is not due to mere rest alone, for the difference in sweat secretion between a resting and a sleeping individual is quite obvious.

To summarize therefore it is generally accepted that during sleep the heart beats slower, the blood pressure is lowered slightly, the respirations are depressed, muscular movements diminished and the sweat secretion increased, especially immediately after the onset of sleep.

Sleep a Parasympathetic Phenomenon

I shall now divert a little at this point from our main topic and say a few words about the sympathetic and parasympathetic

components of the autonomic nervous system. It is now generally recognized that these two components are concerned in the regulation of the physiological function of different organs of the body, and the part they play is usually antagonistic to each other. It has further been recognized that the sympathetic system is a 'positive regulator of preparedness and activity' while the parasympathetic system 'preserves and economizes energy, protects against strain and restores activity' (Hess, 1932). We are more concerned about the parasympathetic in this discussion and therefore I shall say a few words about it to show how it is always working to economize energy and how its effects are brought about in the defence mechanism of the body. Thus a strong light thrown against the eyes will bring about immediate contraction of the pupils to protect the eyes and this contraction is brought about by the 3rd nerve which is parasympathetic. An irritant gas entering the respiratory passages will evoke reflexes which will result in contraction of the bronchioles and this contraction of the bronchioles is again a parasympathetic action through the vagus. If any undesirable food or substance finds its way into the stomach, it will be immediately vomited out through the influence of the parasympathetic. If it goes further down into the intestines, the body defensive mechanism will try to get it out by producing diarrhoea and this process again is governed by the parasympathetic. An increase in the parasympathetic tone will cause the heart to beat slowly and thus prolong the rest period of the heart. The parasympathetic system is, therefore, always alert in protecting the body against strain and exerts its influence in giving rest to important organs of the body.

The main symptoms of sleep such as slowing of the heart, fall in blood pressure and diminished muscular activity therefore prompted Prof. W. R. Hess of Zurich to emphasize that 'sleep' also is a parasympathetic phenomenon 'comparable to the vagus control of the heart'. He pointed out that constriction of the pupils seen during sleep denotes an increase in the parasympathetic tone. Hess also drew attention to the work of Koch (1932) who found that an increase in the carotid sinus pressure of dogs just recovering from an anaesthetic led to an inhibitory state closely resembling sleep and the parasympathetic tone was simultaneously increased. Further, Hess injected drugs like ergotamine, which inhibit the sympathetic activity, into the 3rd ventricle of cats and succeeded in inducing typical sleep. Several experimental observations have since been reported supporting Hess's contention that the parasympathetic tone is increased during sleep. Samaan (1934) for example has shown that the bradycardia in dogs during sleep is due to augmentation of the vagal tone. Some clinical observations also lend support to this view. The value of ephedrine, a sympathomimetic drug, in the treatment of narcolepsy is now well established and shows

the parasympathetic nature of the attacks of sleep that occur in narcolepsy. Similarly, it is a well-recognized clinical observation that attacks of asthma frequently begin during sleep and asthma is more likely to occur when the parasympathetic tone is increased. There is, therefore, considerable experimental and clinical evidence to support the view put forward by Hess that sleep is a parasympathetic phenomenon.

If now we recall the most interesting work of Sir Henry Dale (1934) and his colleagues and a number of other workers showing the close relation between parasympathetic and acetylcholine, and if we admit that sleep is a parasympathetic phenomenon, we are at once confronted with the proposition 'Is acetylcholine the sleep producing hormone ?'

Chemical theory of sleep

Before I put forward before you the experimental evidence which suggests that acetylcholine may act as the 'sleep hormone', I shall make a few remarks about the 'sleep centre' in the hypothalamus and the chemical theory of sleep. The existence of a 'sleep centre' in the region of the 3rd ventricle of the brain was suggested by Mauthner as early as 1890. Economo (1928) concluded from his vast clinical and pathological experience of lethargic encephalitis that the 'sleep centre' was situated in the region where the aqueduct of Sylvius opens into the 3rd ventricle. More recently Hess (1932) demonstrated that electrical stimulation of the diencephalon by specially constructed electrodes promptly produced sleep in cats. Recognition of the 'sleep centre' in the hypothalamus divided physiologists into two schools, holding two different views on the theory of sleep. Those who supported the 'cortical theory' were led by Pavlov (1927) who considered sleep to be a phase of internal inhibition. Pavlov based his arguments from his experiments on conditioned reflexes. He found that an acoustic stimulus, like ringing of a bell, followed by food established a conditioned reflex in dogs. When this reflex was established, just ringing of the bell produced salivation and increase of other digestive secretions, because the dog expected food immediately afterwards. If after establishment of this conditioned reflex the bell is rung but no food presented, the dog often falls asleep. Before the dog falls asleep, however, the flow of digestive secretions is stopped due to inhibition of cerebral centres controlling these secretions. According to Pavlov, this inhibition of localized centres in the cerebrum spreads over to the whole of the cortex and produces sleep. The other school who support the 'subcortical' theory recognize the existence of sleep centre in the hypothalamus and hold that the phenomenon of sleep is governed by this centre. A third school has also arisen who try to subscribe both to the cortical and subcortical theories.

I shall again refer to Pavlov's theory later. Apart from Pavlov's theory the only other theory which has a good experimental background is the 'chemical theory' of sleep first advocated by Pieron (1913). Pieron found that if the cerebrospinal fluid of dogs kept artificially awake for prolonged periods, is withdrawn and injected into the cerebral ventricles of normal dogs, such an injection produced as urgent a desire for sleep in normal dogs, as was manifested by dogs deprived of sleep. He therefore thought that the cerebrospinal fluid of dogs deprived of sleep contained a chemical substance having a hypnotic action and termed this substance 'hypnotoxin'. Pieron's theory was recently supported by the careful work of Schnedorf and Ivy (1939). Since Pieron's publication of his results several substances have been injected into the cerebrospinal fluid of experimental animals and as some of them produced a condition like sleep, claims made for them as 'sleep hormones'. I shall briefly refer to some of them.

Demole (1927) found a decrease in the blood calcium during sleep and thought that the calcium was taken up by the brain centres responsible for sleep. He therefore injected small quantities of calcium in the infundibular region of cats and succeeded in producing typical sleep. These observations were confirmed by Cloetta and Fischer (1930) and La Fora and Sang (1931). Bergren and Moberg (1929) found that mere insertion of needles in the infundibular region produced sleep in animals and previously Gollwitzer-Meir and Kroetz (1924) had failed to find any change in calcium concentration in blood during sleep.

Zondek and Bier (1932) working on the compounds of bromine, found that these are diminished in the Pituitary and increased in the medulla in artificial sleep and therefore postulated that sleep was due to the pouring of 'brome hormone' by the Pituitary gland.

Marinesco and his associates (1929) pointed out that choline injected intracerebrally produced sleep preceded by agitation and increased muscular activity.

Kroll (1933) found that extracts of the brain of sleeping animals, injected intracisternally in cats produced typical sleep. The original sleep was either produced by administration of drugs or was the result of hibernation.

Lastly, I (Dikshit, 1935) injected very small quantities of acetylcholine (in gammas) into the cerebral ventricles of cats and succeeded in producing a condition closely resembling sleep. These results were confirmed in dogs by Schnedorf and Ivy (1939) and to a certain extent in man also by Henderson and Wilson (1937).

It will thus be seen that quite a number of substances have been claimed to act as sleep producing 'hormones' because their direct application to the brain centre or centres produces a

condition resembling sleep. If a chemical substance is responsible for natural sleep, it should, besides its action on the sleep centre, satisfy several other conditions. Thus it must normally be present in the central nervous system, it must not be very stable and its action on the brain centres should be reversible. The presence of a special mechanism in the body to control the activity of this substance will be an additional point in its favour. Moreover, the pharmacological action of this substance on the central nervous system must agree with the physiological changes that are known to occur during sleep. The final proof must, however, rest with the actual demonstration of the fact that this substance accumulates around the sleep centre during sleep and disappears on waking.

If we look at the so-called 'sleep hormones' from these points of view we are at once faced with the fact that none of the substances I have mentioned above satisfies all the conditions. I, however, submit that acetylcholine has been shown to satisfy all of them except the last one. It has not yet been possible for me to put forward definite evidence to say that acetylcholine accumulates in the hypothalamus during sleep and disappears when the animal or subject awakes. I, however, feel that what I am going to say in the next few pages warrants the conclusion that acetylcholine deserves a careful consideration as a sleep producing 'hormone'. The rôle acetylcholine plays in mammalian physiology has been well recognized. We now know how it plays a very important part in the control of voluntary and several involuntary muscles and how it acts as a chemical mediator at the cholinergic nerve terminal. We have also got sufficient evidence to say that it is concerned in the synaptic transmission of the sympathetic ganglia. Is this ester equally concerned as the chemical mediator at the synapses of the central nervous system? The question is yet to be answered, but evidence is gradually accumulating to show that it is (Chang *et al.*, 1937). From this point of view alone the rôle acetylcholine plays in the regulation of the different functions of the central nervous system deserves a careful study.

Is acetylcholine a 'sleep producing hormone'?

I have mentioned above the conditions that a substance should fulfil before it could be accepted as a sleep producing 'hormone'. Let us examine how acetylcholine answers these conditions.

(i) *Action of acetylcholine on sleep centre:*

In a preliminary note read before the Physiological Society of Great Britain it was reported (Dikshit, 1935) that acetylcholine injected in very small quantities (less than 1γ) into the lateral ventricle or into the hypothalamic region of cats produced

a condition closely resembling sleep. These experiments were repeated further and the results mentioned above confirmed. It was also found that the response in different animals varied considerably and it also varied in the same animal. The typical phenomenon of sleep was observed in some animals while in others only drowsiness was evident. In a certain number of experiments drowsiness was preceded by excitation and this occurred more frequently with intraventricular than with hypothalamic injections. These experiments were repeated in dogs by Schnedorf and Ivy (1939). They found that dogs who received acetylcholine into the lateral ventricle passed into a condition closely resembling sleep, while those who received it into the cisterna magna showed only a depression. Henderson and Wilson (1937) repeated these experiments in man. They injected large quantities (up to 7·5 mg.) of acetylcholine intraventricularly in eight patients. The procedure slightly differed in these cases, but the observations were very carefully made and systematically recorded. They found that out of the eight cases who received acetylcholine intraventricularly one passed into profound sleep immediately after the injection, two showed drowsiness but not deep sleep and the remaining five cases no sign of sleep at all. In all these cases, however, nausea, vomiting and intestinal peristalsis were constant effects and so was sweating.

Injections of acetylcholine into the lateral ventricle will naturally affect all centres that line the ventricular system of the brain. A large number of centres will therefore be involved and the reactions will naturally be different from those which one would expect by application of the ester to a localized centre in the brain. The possibility of action on one group of centres nullifying the action on some other group would also exist. Thus the visceral reactions produced by acetylcholine may seriously interfere with the results of its reaction on the sleep centre. Nevertheless, all the experiments quoted above go to show that acetylcholine can produce sleep by its action on the sleep centre.

(ii) *Does acetylcholine exist normally in the brain?*

We are on a more firm experimental basis regarding the presence of acetylcholine in the brain. Since the observation of Schaffer and Moore (1896) that extracts of the brain produce a fall in blood pressure when injected intravenously, there has been a controversy about the nature of the depressor substance in the brain extracts. Some observers like Mott and Halliburton (1899) thought it was choline while others like Vincent and Sheen (1903) did not think it to be so. While working in Edinburgh, I attempted to see if acetylcholine was present in the brain or not and by employing some recent biological tests for acetylcholine was able to show (Dikshit, 1933, 1934*a*) that

it undoubtedly does exist in the brain tissue. Quantitative estimations of different portions of the brain showed that the concentration of acetylcholine was highest in the basal ganglia. Higher concentrations of this ester in the basal ganglia than other parts of the brain are significant when we take into consideration the recent claims, made with increasing insistence, that these ganglia are the seat of a number of visceral activities. These observations were later confirmed by Kwiatowski (1935) and also by Barsoum (1935). Since then a number of workers have not only found acetylcholine in the brain, but have also shown that slices of brain tissue can actually form acetylcholine *in vitro* (Quastel *et al.*, 1936; Stedman and Stedman, 1937; Mahal and Dikshit, 1937; Dikshit, 1938). More recently, Chute, Feldberg and Smyth (1940) have shown acetylcholine formation by the brain in perfusion experiments. One can, therefore, say with certainty that not only is acetylcholine present in the brain but it is formed there continuously.

(iii) *Is there a special mechanism in the body to control the action of acetylcholine ?*

Dale as early as 1914 suggested the possibility of an esterase in the body which would destroy acetylcholine. Several workers since then (Engelhardt and Loewi, 1930; Matthes, 1930) have confirmed this observation. Dr. E. Stedman of Edinburgh and his associates (1932) later discovered an enzyme in the blood which has the specific action of destroying esters of choline and they named this enzyme 'choline-esterase'. A number of contributions by Stedman and his associates and also other workers (Gaddum, 1936) have since then established the rôle that choline-esterase plays in controlling the activity of acetylcholine in the body. It is significant to note that Stedman and Stedman (1936) failed to find any choline-esterase in the cerebrospinal fluid, but found it in large quantities in the brain tissue. Further, they made the important observation that the amount of this enzyme in the basal ganglia was about twice that present in the cortex. We have, therefore, unassailable evidence to show that there exists in the body tissues a mechanism which controls the activity of acetylcholine and that this mechanism—the choline-esterase—is present in the brain and especially in that part of the brain where the sleep centre is situated.

(iv) *Does the pharmacological action of acetylcholine on the brain centres agree with the physiological changes seen during sleep ?*

Earlier I have referred to only four changes that occur physiologically during sleep, changes concerning circulation, respiration, muscular movements and sweat secretion. Action of acetylcholine on brain centres is usually studied by introduction

of the drug into the ventricular fluid of the brain. Such introduction produces action on several centres lining the ventricular system and therefore, as discussed above, information so obtained may be misleading. Moreover, such actions will depend upon the dosage employed and upon the concentration of cholinesterase present in the parts of the brain concerned with these actions. However, it may be stated that as far as the circulation, respiration, muscular movements and sweat secretions are concerned, the action of intraventricular acetylcholine agrees with the changes seen during sleep. I investigated the action of acetylcholine on circulation and respiration (Dikshit, 1934*a*) by injecting small quantities of the drug into the lateral ventricles of cats and found that respiration was definitely depressed and the blood pressure was very slightly lowered by such injections. Depression of respiration and lowering of blood pressure in sleep have already been discussed. Further, I pointed out (Dikshit, 1934*b*) that application of acetylcholine to the brain centres can produce an irregularity of the heart. It is true that every individual does not get an irregular action of the heart just before falling asleep, but in those who are susceptible to such irregularities, it is a common clinical experience that the irregularities are increased at the onset of sleep.

As regards muscular movements, the marked diminution in movements of voluntary muscles by central application of acetylcholine can be demonstrated in animals who are just recovering from a volatile anaesthetic. Under deep ether anaesthesia, a trephine hole is made in the skull of a cat to introduce acetylcholine into the ventricles. The muscular movements are registered graphically by placing two large balloons partially filled with water on two sides of the animal and connecting both to a recording tambour. The anaesthetic is then lightened and as the animal comes into the first stage of anaesthesia it begins to struggle and these movements are registered on a moving kymograph. A small quantity of acetylcholine (1 or 2γ) is then introduced into the lateral ventricle through the trephine hole and the effect of the injection is seen immediately afterwards. The struggling movements become less and less and sometimes they are completely abolished for a short time. In experiments described previously, introduction of acetylcholine into the cerebral ventricle of unanaesthetized cats led to a condition resembling sleep and thus was associated with lessened muscular tone and movements. Therefore, action of acetylcholine on voluntary muscular movements is similar to the action seen physiologically during sleep.

Secretion of sweat is difficult to demonstrate in the experimental animals. Cats have a few sweat glands on the foot pads, but it is difficult to demonstrate increase in secretion of these glands. In their experiments on hospital patients, however, Henderson and Wilson (1937) found sweating to be almost

uniformly associated with intraventricular acetylcholine injection. According to these authors sweating accompanied nausea but was present in some cases to a degree which was much more than could be found in nausea alone and in others it was profuse. Sweating after sleeping is a common observation when environmental conditions are suitable for sweating. Such conditions are naturally present more often in the tropics than in colder climates.

It will thus be seen that the pharmacological action of acetylcholine on the brain centres and the physiological changes seen during sleep agree at least on those points which I have just discussed. There is one important discrepancy, however, which was noted by Schnedorf and Ivy (1939) in their experiments on dogs. They observed that intraventricular injections of acetylcholine produced sleep in dogs but the rectal temperature was simultaneously raised. Rise in temperature is not a phenomenon observed in natural sleep and therefore Schnedorf and Ivy (1939) were inclined to believe that the response to acetylcholine was not truly physiologic. Henderson and Wilson (1937) on the other hand found a drop in body temperature after intraventricular acetylcholine injections, but they were working with human subjects who responded with perspiration to acetylcholine and perhaps this sweating helped to lower the temperature. Dogs cannot perspire and therefore Schnedorf and Ivy could not notice a fall in temperature. It is interesting to note in this connection, however, that Shiziraku (1925) kept dogs artificially awake for prolonged periods and when their desire for sleep was extreme a rise in their body temperature was noted.

Temperature regulation is governed by a special centre in the hypothalamus and it is not possible to say whether the fall in temperature during natural sleep is due to the action of the 'sleep hormone' on this centre or due to vascular changes and diminished motor activity. I shall, however, again take the liberty to repeat what I have said before that intraventricular injections of acetylcholine produce a much more diffused action on the brain centres than local liberation of the ester in certain localized parts of the brain would do.

(v) *Is there accumulation of acetylcholine in the sleep centre during sleep?*

We now come to the crucial test of this 'sleep hormone' theory, viz., demonstration of accumulation of acetylcholine in the sleep centre during sleep. I must state in the beginning that all my attempts to get this proof have failed so far. The problem is associated with a number of technical difficulties. Acetylcholine is very rapidly destroyed by the enzyme, cholinesterase, and any experimental procedure in a sleeping animal

disturbs it and leads to the waking state. I therefore decided to tackle this problem indirectly and shall describe very briefly the nature of experimental procedures I have adopted.

(a) Relation between choline-esterase in blood and acetylcholine concentration in the brain :

In a paper read before the Indian Science Congress (Dikshit, 1937), I had mentioned that there is a direct relationship between the acetylcholine concentration in the brain and choline-esterase content of the blood. These experiments were made on different species of animals and it was found that whenever there was a high concentration of acetylcholine in the brain, there was also a high concentration of the enzyme in the blood. This relationship was noticed by Dr. Stedman, F.R.S., of Edinburgh some years previously. It was therefore thought that examination of the blood of a subject might give an idea about the acetylcholine concentration in his brain. We therefore examined the blood of several volunteers at noon and at midnight with a hope of finding a difference in the choline-esterase content of the two samples of blood but failed to find any such difference whatsoever. Further, Dr. Mahal (1938) working in my laboratory in Bombay examined the blood of guinea-pigs which were kept artificially awake for several days and found no difference between the choline-esterase concentration of the blood of these animals taken before and after prolonged sleeplessness.

(b) Appearance of acetylcholine into the cerebrospinal fluid of animals deprived of sleep :

I kept cats artificially awake for several days and examined their cerebrospinal fluid to see if any acetylcholine could be detected in it. The cats were deprived of sleep by putting them in a slowly revolving cage. In such experiments the animals have to move all through 24 hours and the experiments are complicated by a third factor of muscular fatigue. However, I failed to see any appearance of acetylcholine in the cerebrospinal fluid of these animals after prolonged wakefulness. Schnedorf and Ivy (1939) made more careful experiments with dogs and also failed to find any acetylcholine in the cerebrospinal fluid of dogs deprived of sleep. The idea in these experiments was that if acetylcholine accumulates in large quantities around the sleep centre it may partly escape into the cerebrospinal fluid and its presence in this fluid could be detected by employing sensitive biological tests. Normal cerebrospinal fluid contains no acetylcholine and no enzyme. The enzyme which is present in the brain tissue however appears to destroy acetylcholine completely and not the slightest trace of the ester appears in the cerebrospinal fluid.

(c) *Estimation of acetylcholine in the basal ganglia of animals deprived of sleep:*

These experiments were made on guinea-pigs and rats. The animals were kept awake by putting them in a revolving cage and therefore the factor of fatigue was present in these experiments also. After five days of sleeplessness when the guinea-pigs were taken out of the cage they exhibited the most urgent desire for sleep. Such animals were killed immediately after removing from the cage and the acetylcholine content of the basal ganglia estimated and compared with that of normal animals. In the beginning I got the impression that I was finding more acetylcholine in the basal ganglia of sleepless animals as compared with normal ones, but the individual variations were found to be far too wide to arrive at any definite conclusion. Similar results were obtained with rats also. I feel that this procedure may give some information if a very large number of animals is used and the results studied statistically.

(d) *Effect of Physostigmine:*

The action of physostigmine, an alkaloid obtained from the calabar bean, in preventing the hydrolysis of acetylcholine by the specific enzyme is now well established. Hydrolysis of acetylcholine by the enzyme in the brain could therefore be prevented by administration of this drug and if this drug could be administered in sufficient quantities to neutralize the enzyme action, sufficient accumulation of acetylcholine could occur in the brain to produce its central effects. Unfortunately, however, the drug is far too toxic to permit of its administration in adequate doses. Besides, the side actions of such administration are far too powerful to enable the phenomenon of sleep to be studied. It is interesting to note, however, that the central depressant action of physostigmine has been recognized and Sollmann (1933) mentions that this depressant effect has been made use of clinically in diseases like epilepsy though without much success. Mention must, however, be made of the experiments of Dost (1934) in this connection. To test Hess's theory of sleep Dost injected a large number of drugs intramuscularly in cannaries, physostigmine being one of them; and he found injections of physostigmine produced sleep in these birds. Further, one of my colleagues working in the Royal Infirmary of Edinburgh gave Miotin, a compound prepared by Stedman which has identical action as that of physostigmine, to a patient and found that after the preliminary visceral effects had passed off the patient fell into deep sleep. Physicians and surgeons have, these days, many opportunities of using prostigmine or physostigmine in their clinical work and if observations are made with special reference to sleep, I think such

clinical data will materially help to verify the theory of sleep I have postulated.

However, to come back to the effect of physostigmine in animals, I gave this drug hypodermically to cats, dogs, and monkeys. As explained above, the visceral effects of such injections were far too severe to allow the phenomenon of sleep to be observed properly, but after these effects wore off, a definite drowsiness was observed in some of these animals.

DISCUSSION

The remarkable experimental work of Pavlov (1927) on conditioned reflexes has shown that sleep is due to spread of internal inhibition. I have already referred to Pavlov's work and explained that Pavlov holds the cortex entirely responsible for sleep. Goltz (1892) on the other hand has shown that decorticated dogs can sleep and this observation was confirmed by others (Rothman, 1923; Rademaker and Winkler, 1928). If dogs without cortex can sleep, Pavlov's hypothesis cannot be entirely correct. Criticism has also been levelled against Pavlov's experiments. Kleitman (1929) observed that in some experiments on activity of gastro-intestinal tract made in his laboratory he had to use stands similar to those used by Pavlov and he often noticed dogs sleeping, though no conditioned reflexes were involved. He also mentions a case in which a dog continued actively secreting saliva though asleep and inhibition of salivary secretion followed and did not precede onset of sleep.

If sleep is a conditioned reflex, it is not possible to understand how a new-born baby can sleep from the moment it is born. The diurnal variation in sleep and activity of monophasic animals could be understood on the conditioned reflex theory, but not the sleep of polyphasic animals who have sixteen periods of rest and activity during 24 hours. Another important question is, does the sleep of lower forms of vertebrates, for example that of frogs or fish, depend on conditioned reflexes or is their sleep different altogether from the sleep of higher vertebrates ?

It is, however, not possible to deny that conditioned reflexes play an important part in the diurnal periodicity of sleep, at any rate sleep of higher animals. We are accustomed to sleep under certain conditions and any trivial change in these conditions, such as an uncomfortable bed or a different bed room may be sufficient to prevent sleep. The diurnal periodicity of sleep in man is more a habit than a physiological necessity and is therefore, as Pavlov says, dependent on the cortex.

Sleep as a physiological necessity is, however, a different proposition altogether. In a normal individual an uncomfortable bed causes sleeplessness for a night or two, but there will always be a limit to this sleeplessness. The necessity of sleep after

prolonged wakefulness is so urgent that a person can sleep in most adverse conditions. Instances have been mentioned during the Great War when people riding or marching were actually sleeping. Animals deprived of sleep for long periods can sleep in most unusual positions. In such instances conditioned reflexes could play but little or no part; sleep as a physiological necessity therefore cannot be said to be under the influence of the cerebral cortex and the function must be relegated to sub-cortical centres. I have already referred to the evidence which has accumulated in support of the existence of a sleep centre in the hypothalamic region. The experimental evidence I have put before you is based on recognition of this sleep centre. How is this sleep centre activated? This is the question for which an answer is sought and I have presented to you some facts which tend to show that acetylcholine could be considered as an agent which can lay some claims as a sleep producing 'hormone' which activates the sleep centre. I frankly admit that the evidence I have presented is more indirect than direct. It has not been possible to demonstrate actual accumulation of acetylcholine in the sleep centre during sleep. Attempts to demonstrate it in the cerebrospinal fluid of animals deprived of sleep have failed in the hands of others as in my hands. My attempts to show its increased concentration in the basal ganglia after prolonged sleeplessness have given equivocal results. Indirect approach to the problem by estimation of blood cholinesterase have given no indication.

On the other hand, the indirect evidence is not very meagre. The importance of acetylcholine in physiology coupled with Hess's contention that sleep is a parasympathetic phenomenon and Dale's contribution explaining the rôle acetylcholine plays in parasympathetic phenomena gives a clear ground to work upon. Existence of acetylcholine in the brain, its higher concentration in the basal ganglia, and the presence of a special mechanism to regulate the activity of acetylcholine are important data supporting the view. Agreement between acetylcholine action on some brain centres and the effects of sleep on these centres also is in favour of acetylcholine being a 'sleep hormone'.

I am fully aware of the fact that I have discussed the problem of sleep from a very restricted point of view. I have not made reference to many other approaches to the subject like the recent researches on the brain potentials during sleep. I have also refrained from discussing other theories of sleep, because such a discussion would have been outside the scope of this address. There are many other points which will have to be investigated before the theory I have put before you is finally accepted. If acetylcholine is responsible for sleep, is there any other hormone which brings on awakening? Is the sleep of higher vertebrates and lower ones, like frogs and fish, similar?

What is the nature of the sleep of lower forms of life like earthworms? Do they sleep at all? Do plants sleep? Is there any disturbance in the acetylcholine metabolism of the central nervous system in certain psychopathies or mental disorders? These and similar questions will naturally arise and it is my earnest hope that attempts will be made to answer them by further experimental and clinical research.

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SECTION OF PSYCHOLOGY AND EDUCATIONAL SCIENCE

President :—I. Latif, M.A., Ph.D.

Presidential Address

(*Delivered on Jan. 7, 1941*)

PSYCHOLOGY AND THE FUTURE OF MANKIND

I

The history of the civilized world presents a sad record of the repeated failures of human society to ensure the sanity and stability of mankind. Thousands of years have passed since man forsook his savage haunts and modes of living, and entered the domain of civilization with high hopes and expectations for a brighter destiny—only to find himself involved in far more serious perils. Not only does he find himself in greater perils to his physical safety from the antagonistic assaults of his fellow-creatures but he is also constantly exposed to graver dangers to his sanity from the various factors inherent in the very nature of civilization. The perils to his physical safety have been tremendously increased by the use of scientific instruments of human destruction. Man's control of the instruments for destroying his fellow-creatures has reached such a remarkable degree of perfection, that the very existence of the human species appears to be seriously jeopardized. The dangers to his sanity have become increasingly threatening with the irrational control which civilized society has come to exercise over his fundamental natural urges. This latter danger is so fatal to the health, sanity and efficiency of the individual, that it appears that this civilization, in whose friendly support man had placed his implicit confidence, is likely to prove his most dangerous foe. His supposed safety and stability within civilized society is now being exposed as an illusion and the destiny of the human race is becoming increasingly dark and uncertain. Even the belief that there has been a steady progress of reason during the history of the human race is now fast vanishing.

The usual arguments of the protagonist of modern civilization concerning the manifold advantages of the scientific research of their times, as a rule, leaves out of account the fact that the scientific achievements of our age have gone beyond man's ability rationally to control them. Consider, for instance,

how the modern devices for the intercommunication of news and thought, which were expected to unite human family closer together in greater understanding and tolerance, have served to aggravate the traditional hostility and national arrogance of men. And when we think of the ways in which the fruits of the scientific labours of man have been used for the destruction of mankind, the conviction grows on us that these are by no means the 'unqualified enrichment' of human life that some people claim them to be.

The uncertainty concerning the future of the human race which distresses the student of civilized society today is the logical result of the general discredit into which the redemptive efforts of many generations of civilized mankind have now fallen. Each generation in turn takes up the task of redressing human society with high expectations—only to find humanity involved in a progressively worse plight. Every day brings to light evidence of the antagonism, hatred, competition, indifference and hostility which continually complicate social and international relations. To take only one instance, consider the ever-recurring international conflicts in Europe in spite of continuous efforts to ensure a peaceful settlement. Within the last one hundred years European history records the Boer War, the Franco-Prussian War, the War between Germany and Austria, the War between Prussia and Denmark, the Franco-Sardinian War against Austria, the Crimean War, the British Opium War, British actions in Africa, China, Palestine and elsewhere; French actions in Africa and Mexico and a host of other such conflicts down to the present war. What strikes the student of human nature is not so much the actual event of war as the constancy with which it repeats itself in spite of all the conscious endeavours of mankind to ensure a rational and peaceful state. The last world war, for instance, exhausted the strength and national resources of all the countries involved; and yet the survivors so far from disarming started arming again feverishly. Thus after four years of ruthless slaughter, and after world-wide conferences to ensure a sane and peaceful human society, Europe remained an armed camp—preparing for new wars and conquests.

A study of the available records concerning the sanity of man in civilized society reveals appalling facts and figures. The number of the victims of psychogenic disorders is definitely on the increase. These disorders are ultimately due to man's lack of emotional adjustment to the rigid demands of his cultural environments; they include neurasthenia, hysteria, anxiety-neuroses, phobias, obsessions and so forth. A large number of mild cases belonging to this classification still go unrecognized under the false diagnosis of anaemia, insomnia, gastric catarrh, debility, etc., rendering the therapeutic endeavours of orthodox medical systems futile. During the brief space of three years

24,000 suicides or attempted suicides were entered in the Archives of the Board for the Prevention of Suicides in Budapest. According to the report of one leading medical investigator, this city holds the world record for attempted suicides. The records of the United States of America show 150,000 suicides annually. Many other similar records might be quoted to show the extent to which the neurotic illness infests civilized society today. The case-histories of psychological clinics in any civilized city could yield additional evidence of the actual increase of neurotic disorders, domestic and marital disruptions and maladjustments.

Nor do the records of antisocial behaviour relieve the dismal perspective. The subtle and ingenious forms in which crime is progressively thriving in our modern society and the heavy toll it lays on our economic resources provide further evidence which destroys the individual's belief in the ability of civilization to satisfy all the rational demands of its members. The various forms of delinquency are so manifestly a repudiation of social conventions and taboos that we are forced to conclude that civilization does not satisfy all the demands of human personality, and in consequence a large number of its members are provoked to fly in the face of its laws.

We repeat that the great tragedy which attends the march of human affairs does not consist so much in these events which blight the history of the human race, as in the vicious circle in which mankind appears to be inextricably involved, so that mental disorders, crimes, political unrest, wars and unhappiness dog its steps at every turn.

II

But the most pathetic aspect of the situation is the profound ignorance of the leading intellectuals concerning the real causes of the manifold disorders with which mankind is afflicted. Consequently, little or nothing has been done to alter this situation. For, it must be adequately diagnosed before it can be remedied.

This seems to be an extraordinary instance of gross ignorance in an 'age of scientific enlightenment'. For, not only are we struck by the paucity of literature offering an adequate explanation of the causes which have conspired to bring about this situation but we find that the alleged explanations of a majority of those who have attempted to study this particular subject leave us, in the end, confused and mystified. Most of these tend to confuse the various issues involved in the situation. Moreover, they almost invariably suffer from a fundamental error which consists either in entirely ignoring the influence of the human factor in the aetiology of the present social disorders or conceding to it only a secondary and casual importance. In this way the root cause of the trouble is almost invariably

miscalculated. Irrelevant factors are frequently exalted into all-sufficient causes; and grandiloquent attempts are made to convince individuals that it is through the control of these causes that the final redress of human wrongs will be effected. Meanwhile little or nothing is done to explore the mental dynamics of the *homo sapiens* in a scientifically objective manner in order to discover the underlying causes at work. Thus having omitted or miscalculated the importance of the human factor, such studies are inevitably superficial, even when they are not wholly irrelevant.

Recent psychological enquiries into the individual and social behaviour of man are making it increasingly clear that apart from the scientifically objective study of the mental dynamics of the human behaviour it is not possible to understand adequately and remedy effectively the present trouble so as to ensure the sanity and stability of the human race. Without the help of psychopathological insight and technique, the situation will for ever remain an inextricable mystery and a constant menace to mankind. In the words of Samuel D. Schmalhausen: 'Whatever field of life we touch, straightway we are in the presence of problems of maladjustment. Whether we go over the field of criminology, juvenile delinquency, marriage and divorce, business relations, the institutions of the home, the church, the state, the school, or study the intricate taboos and sacred sanctions of ethical codes or peer into the mob-intricacies of journalism, or specialize in the phenomena of crowd behaviour, persistently and inseparably we are in the perturbing presence of problems that can only be approached intelligently from a psychiatric point of view. History, penetratingly conceived, is a branch of psychoanalytic psychiatry.'[1]

Of the several factors which have conspired to obscure the importance of the knowledge and application of the findings of psychological research in the scientific study of human affairs, we shall mention only a few here. In the first place, the extraordinary progress of the physical sciences has naturally led to the obscuring of the value of psychological science and the relegation of the mental determinants of human behaviour into the background. Man's discovery of physical laws and the utilization of the knowledge which enables him to deal with forces as they are manifested in the external world has outstripped his knowledge of the dynamic determinants of his behaviour. He is obsessed with the thought that since the knowledge of the laws of his physical environment have given him control over the world, the same laws will ensure his control over his own destiny. Consequently, an explanation of behaviour in terms of mental dynamics is relatively neglected. This physical bias characterizes the mental outlook of a majority of our leading scientists. Some

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[1] *Why We Misbehave*, pp. 71-72.

of them even go to the length of regarding a psychological approach as wholly irrelevant to any serious scientific endeavour at explaining and controlling the trend of human affairs. They even question the right of psychology to the status of a science. Very often the presence of a psychologist at a congress of scientists is regarded by them as anomalous if not altogether unwelcome. It is the physical scientist who truly represents the cause of science. The psychologist is a scientist only by courtesy. It is but natural that this indifference to the science of human psychology should darken counsel and render a majority of the explanations of physical speculators only partial endeavours at best.

In order to illustrate how indifference to psychological facts may distort one's explanation of human behaviour, we may take an instance from the speculations of those who claim to explain human activity exclusively in terms of economic laws. They treat of wealth as entirely independent of the laws of human psychology. Of course there is now a growing tendency to make a passing reference to the psychological aspect of economic transactions in the opening chapter of the text-books on the subject. But the casual and superficial character of these references often makes one wonder whether this is not merely an attempt to impress the reading public with the idea that psychological aspects of the science, if any, have been taken account of. The fundamental economic problems continue to be treated with the usual indifference to the laws of human psychology. The rise and fall of prices, the supply, demand and consumption of commodities are treated as if they were governed by laws outside the field of human psychology. Ignorant of, and indifferent to, the fundamental relation of the laws of human psychology to this field of human activity, economic speculators have repeatedly landed multitudes of credulous individuals in disastrous crises. But when we consider some of the solutions proposed by economic enthusiasts for the problems of social disorder, the superficial character of such explanations when unaided by the knowledge of human psychology, becomes even more obvious. For example, it has been a current belief in Soviet Russia that the only way to eradicate the criminal tendencies of an individual is the liquidation of economic inequality. Equal economic opportunities, it is claimed, will in the end result in the gratification of human needs so that no one will desire to prey upon the economic resources of society by antisocial methods. We freely concede that removal of unequal opportunities for earning wealth does in certain cases prevent antisocial behaviour. Our main objection to this claim, however, is that quite a high proportion of adult delinquents do not begin their criminal career on experiencing economic strain. Kleptomania, for instance, may find expression in the behaviour of well-to-do individuals.

Psychoanalytic research has shown that very often a conscious economic want may be only a disguised and repressed erotic wish. In a fairly large number of cases wealth or money has been discovered to possess this erotic significance. Not until this aspect of the overt human activity is scientifically explored can one assert with any degree of scientific certitude whether or not a specific instance of individual conduct, which to all appearances is the product of economic conditions, is really independent of deeper psychological motives. Not until this has been duly taken into consideration can we expect to have a scientifically complete explanation of the specific behaviour in question. 'However great our faith in the environmental determinants of human behaviour, in the truly astonishing power of economic and social forces to shape and mis-shape our lives, we shall be missing an amazing amount of insight if we ignore or minimize the importance of the human nature factors such as the psychoanalysts and the dynamic psychopathologists deal with . . . . There is a lurid chapter in the history of human conduct that has very little to do with specific economic determinants but has a great deal to do with certain distortions and perversions resident in human nature.' [1]

This brief discussion of the economic motive of human conduct will help us to understand how indifference to the laws of human psychology can obscure the true nature of the causes which are responsible for the present social disorders; and how ignorance of these causes renders the hope of their redress lamentably remote.

It has often been alleged that the relative youth of the science of psychology is responsible for the indifference with which its findings are treated. But when we consider the amazing progress which this science has achieved within the few decades of its career, we shall be obliged to look for a deeper reason. Its youthfulness would still leave the possibility of making use of the existing psychological knowledge open to a large majority of thinkers in the field of the social sciences. But it is not only the general indifference of leading thinkers but often their positive hostility to the science of psychology which requires a scientific explanation. Barring those provocative examples of certain philosophizing psychologists and the sterile stunts of 'brass-instrument' psychologizing enthusiasts, which may have brought discredit to this science, we shall find that this indifference and hostility to psychology can be traced, in the last analysis, to the great unwillingness of man to face himself. It appears that a large majority of the opponents of psychology are people who by the rigid restraints of modern culture are unable to encounter calmly the contents of their own mental make-up. Their indifference to this science is, to

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[1] Schmalhausen: *op. cit.*, p. 73.

a large extent, a defence mechanism against the possibility of the revelation of certain mental dynamics which are, so to speak, looked upon as contrabands within the social environment of modern culture. This ostrich-like attitude serves as a narcotic to lull them into a self-complacent slumber. What these mental contrabands really are we shall explain presently. Meanwhile it may help us to understand their provocative character if we remember that the history of modern culture records innumerable instances in which the flood of social disapproval and hostility has been directed against any objective study of human nature which may throw light on certain instinctual demands which have been tabooed by the conventions of civilization. With his extraordinary insight into this fact Sigmund Freud has clearly demonstrated how human beings can ill-afford to endure any shock to their narcissistic self-complacency and that contempt for any scientific technique which bids fair to ensure self-knowledge to the individual is very often used as the principal weapon of the resistance. This resistance incidently is a measure of the mental health of modern society. For a society which does not have the courage to examine its own motives must be basically sick.

III

Let us consider for a moment what may be the contents of this self-knowledge so that we may be able to understand why civilized man should invariably build up such a strong resistance against it. But we must first disabuse our minds of the popular belief that the mental structure of the civilized individual is fundamentally different from that of his savage ancestors. This prejudice has largely obstructed an objective study of the determinants of human behaviour, and not until we discarded it shall we be in a position to observe the contents of the human mind in their true nature and setting. The vast and varied data now available in the field of psychoanalytic research clearly indicate that fundamentally the same mental dynamics which motivated the behaviour of his savage ancestors thousands of years ago, still, under the gloss of modern culture, continue to determine the conduct of modern civilized man. Whatever the cultural standards of his society, under the influence of a strong emotional experience or of a threat to his personal interest, man's primitive impulses break through his cultural restraint. 'Any emotional stress, a sudden panic, a threat of calamity, a failure in business or in marriage, a severe illness, the death of a loved one, and it is liable to stampede man into conduct prejudicial to himself and to his neighbours. It may even bring about his own destruction.'[1] Such observations clearly show that behind man's

[1] Glover, E.: *The Dangers of Being Human*, p. 49.

facade of rational conduct there exists a primitive mental structure which regulates his individual and social life.

By the primitive mental processes we mean such motives to conduct as animistic beliefs, totemistic taboos, and a thousand forms of hostilities, fears and irrationalities. A large number of these are subtly disguised in modern culture so as to elude recognition without the aid of a special psychological technique. Thanks to the mechanisms of repression and displacement they flourish undetected by the victim. The notion that modern man has evolved beyond the mental stage of his savage ancestors keeps him in the dark with regard to their existence within his mental structure and thus less vigilant against their destructive power. This is the chief danger of modern civilization. It harbours within itself mental mechanisms of extreme destructive potency and it is incapable of defending itself against them because it is unconscious of their very existence. And yet without recognizing their existence, one would be wholly at a loss to account for the 'inhuman atrocities', the hatreds, hostilities, and wars, the savage superstitions, the neurotic disorders and psychotic manifestations of the individual which flourish unabated today even in the most 'advanced' civilized societies. The dismal catalogue of 'hallucinations, obsessions, delusions, paranoid trends, moods running the whole gamut of manic-depressive psychoses, psychoneurotic tensions and unstabilities, organic and functional inferiorities, phobias, hysterical outbreaks, tendencies to melancholia, sexual perversions, narcissistic attitudes, egoistic indulgences, exhibitionism, insane ambitiousness, anxiety, compulsions, habit neurosis, automatism in behaviour' is the logical result of the clash of primitive impulses with the conventions of civilization. This alone can account for the hostile character of the international relations today, which can clearly be traced to these savage mental processes which continue to operate under the civilized gloss of the present day culture. Theoretically international problems should call for rational remedies. But how rarely in the history of civilized society have people found it possible to wait long enough for a rational redress of wrongs. Under provocation, the inflammable savage impulses of our nature burst forth into terrible conflagration. Modern man has not been able to shake off the influence of the primitive processes which existed in the darkest phases of human development.

The failure of civilized society to put an end to warfare illustrates the impossibility of ensuring peaceful settlement so long as its members do not clearly realize the existence of the forces in their personality which invariably bring about war. The main trouble with the efforts to put an end to the war is that they have been directed against wrong objectives. For instance, they have been based upon the assumption that disarmament of an opponent is the only effective method of putting

an end to war. The idea is not at all new, and is only a slight variant of an ancient maxim that 'to despoil our neighbours deprives them of the means to injure us.' Accordingly the repeated failures of peace organizations to stop war have been attributed to the incomplete disarmament of hostile nations rather than to the failure of political leaders to intelligently understand and rationally control the determinants of human behaviour whose operation invariably issues in war. The possession of destructive weapons is only a secondary consideration. Mental determinants are the primary causal factors. So long as the basic motives of war are not psychologically diagnosed and controlled, mere legislation on the control of armaments cannot eradicate war. The control of armament will only limit the extent of destruction; it cannot eradicate aggression, hostility, fear, competition, megalomania which invariably produce war. A clear and objective understanding of the significance of these urges is the first step towards preventing war. Without this essential step peace organizations, international conferences and treaties and diplomatic negotiations are entirely powerless to stop war.

But here again it is the misfortune of civilized man that he fondly hugs the illusion that he is beyond the influence of the motives which provoked his savage ancestor to warfare. Owing to the mechanism of repression, if he should by any chance attempt to look for the causes of human warfare within his own nature, the result would be negative. Consequently, he explains war in such a way as not to hurt his sense of self-complacency. He projects his own primitive motives upon his opponent whom he regards as a savage or a lunatic, and whom he deems it a moral obligation to resist. It is obvious how the conventions of civilized society invariably regulate the specific pattern of the behaviour of modern belligerents. It is not a pure accident that each of the combatants unconsciously realizes the need of rationalizing his motives for war by convincing himself, and very often others of his party, that he is fighting for a righteous cause and not for any form of self-interest. How often in the history of civilized society has man unconsciously or otherwise attempted to exonerate himself for indulging in savage human destruction by labelling it a 'holy war'. War in savage societies was not so subtly disguised.

But though the motives of warfare were more or less clear to the savage, they were not any the less dangerous. All wars, whether waged by civilized or primitive groups, threaten the stability of the human race and the peace of human society. But with the undisguised knowledge of the motives, the savage was in a better position to control the event of war, at least on theoretical grounds, when he so desired. But curiously enough, none of the civilized organizations which aim at the prevention of war have ever spent a single penny for a scientific investigation

and control of the mental conditions which produce war. Only when the nations are able to perceive these mental forces and recognize their real nature in a frank and fearless manner, will it be possible to prevent war through the emotional re-education of its members.

It may be contended that though true of certain individuals under strongly provocative circumstances and peculiar mental outlook, our statement of the operation of the savage processes in the life of the normal civilized man is a gross exaggeration. But the objective study of the so-called normal individual of our age, does not offer any different perspective. Few of us spend more than a few hours during the entire day in a completely rational state of mind. And when the rigid demands of our social and professional life leave us to ourselves for a moment, we naturally tend to relapse into modes of behaviour which under analytic examination are clearly primitive and irrational. Two lines of evidence may be advanced to confirm the truth of this statement: (*a*) the psychopathological study of the adult individual behaviour; (*b*) the genetic study of the mental life of the individual. Both of these lines of evidence converge on the truth of the statement that the mental processes of the modern man, in spite of the cultural demands of his society, are inherently and basically primitive. The infant, in the modern society, before the code of modern civilization influences his conscious behaviour, undisguisedly manifests the same hostilities, rivalries and irrational fears which find devious and disguised expressions in the behaviour of the adult within his cultural environment. The psychoanalytic study of the dreams of apparently normal individuals clearly brings out the savage character of their dominant wishes and desires.

IV

When we set out to inquire how it is that the savage elements of our nature remain generally unrecognized in our conscious mind, we are naturally led to the consideration of certain psychological devices to which references has already been made. The mechanism of 'repression'—a process through which an impulse which comes into conflict with a strong cultural demand is driven into the unconscious—is obviously at work here. This process is further aided by another unconscious mechanism called projection through which the individual unconsciously responds to the conflicting urge by an effort to deny its existence within himself and by attributing it to an external object. The latter, to some extent, accounts for the extraordinary conviction with which certain paranoics attribute guilty motives to their neighbours. This also to a very large extent explains the abnormal zeal of the religious fanatic or the hypercritical prude. The more violent their condemnation of others, the

stronger their repudiation and fear of these impulses within their own lives. 'The real motives of the reformer,' says Hendrick, 'who consciously believes he is protecting others' morality and unconsciously enjoys a mass of obscene literature in the rôle of public censor are commoly recognized.'

The intensity of repression depends upon the extent to which conventional ethics has been allowed to impose upon the human individual an ideal of conduct in total disregard of the instinctual demands of his nature. Renunciation of instinctual urges is the fundamental requirement of conventional morality. In obedience to this man's aggressive, vindictive, and erotic urges have in the course of civilized culture been blindly subjected to a progressive process of repression. 'Civilization,' says Sigmund Freud, 'is the fruit of renunciation of instinctual satisfaction, and from each new comer in turn exacts the same renunciation.'[1] He goes on to describe the various psychological moments of the process so clearly that we shall quote his own words: 'Civilized society, which exacts good conduct and does not trouble itself about the impulses underlying it, has thus won over to obedience a great many people who are not thereby following the dictates of their own natures. Encouraged by this success, society has suffered itself to be led into straining the moral standard to the highest possible point, and thus it has forced its members into a yet greater estrangement from their instinctual dispositions. They are consequently subjected to an unceasing suppression of instinct, the resulting strain of which betrays itself in the most remarkable phenomena of reaction and compensation formations. In the domain of sexuality, where such suppression is most difficult to enforce, the result is seen in the reaction-phenomena of neurotic disorders. Elsewhere the pressure of civilization brings in its train no pathological results, but is shown in malformations of character; and in the perpetual readiness of the inhibited instincts to break through to gratification at any suitable opportunity. Anyone thus compelled to act continually in the sense of precepts which are not the expression of instinctual inclinations, is living, psychologically speaking, beyond his means, and might objectively be designated a hypocrite, whether this difference be clearly known to him or not. It is undeniable that our contemporary civilization is extraordinarily favourable to the production of this form of hypocrisy. One might venture to say that it is based upon such hypocrisy, and that it would have to submit to far-reaching modifications if people were to understand to live in accordance with the psychological truth. Thus there are very many more hypocrites than truly civilized persons—indeed, it is a debatable point whether a certain degree of civilized hypocrisy be not indispensable for the maintenance of civiliza-

[1] Collected Papers, Vol. IV, p. 297.

tion, because the cultural adaptability so far attained by those living today would perhaps not prove adequate to the task. On the other hand, the maintenance of civilization even on so questionable a basis offers the prospect of each new generation achieving a farther-reaching transmutation of instinct, and becoming the pioneer of a higher form of civilization.'[1]

Thanks to the endless drill in man's loyalty to the abstractions of conventional ethics ever since the hour of his birth, he tends to exalt its dictates of conduct into immutable laws like those of the Medes and Persians. Instead of accepting his lapses in the field of conventional morality as the natural result of its artificial and preposterous demands, man has developed a sense of defeatism and morbid anxiety which have invariably interfered with his happiness, sanity and efficiency. Indeed, the code of conventional morality demands more sacrifice than it is worth. Its standard of conduct is neither directed by honesty nor instituted by wisdom.

When we turn to the field of the religious behaviour of mankind, we observe an equally disappointing situation. In spite of the highly organized institutions which have been erected to bolster the preposterous demands and claims of the various pseudo-religious systems, one cannot help noticing the subtle and seductive operation of certain primitive emotional forces in this type of behaviour which have proved refractory to man's rational control. Dispassionate studies of this field of human behaviour have served to expose the various totemistic beliefs and taboos, magical incantations and obsessional ritualistic observances which persist in it in an endless series of modern versions and which have to a large extent thrown man's intelligence out of function. Perhaps in no other field of human behaviour have morbid fear, infantile egocentricity, credulity, intolerance, illogicalities and intellectual dishonesty found such frequent and free expressions. 'Where questions of religion are concerned,' observes Freud, 'people are guilty of every possible kind of insincerity and intellectual misdemeanour.'[2] Psychoanalytic research has brought to light the neurotic character of the morbid religious attitude of man. It has shown that the pseudo-religious behaviour of man is the continuation of the obsessional neuroses of childhood and of the emotional irrationalities of his savage ancestors. A further line of evidence shows that certain modes of morbid religious behaviour are only disguised or symbolic ways through which certain individuals unconsciously gratify their suppressed wishes. Take the case of a sadistic individual who derives perverted pleasure from inflicting pain on others. There being few other avenues for the gratification of such pathological impulses without the

[1] Vol. IV, pp. 299-300.

[2] Freud, S.: *The Future of an Illusion*, p. 56.

risk of social disapproval, such people often find a congenial atmosphere in the field of religious expression. The tension of their sadistic impulses finds relief in moral and religious denunciations, pious vituperations and scathing criticism of their neighbours. Since modern society hardly tolerates a cannibalistic form of human torture, at least under conditions of peace, one's sadistic impulses are as a rule restricted to such verbal assaults. Sadistic impulses often flourish under the guise of fanatic zeal. Likewise masochistic impulses very often find expression in the self-humiliating, self-torturing, ascetic ceremonials of pseudo-religious behaviour. Thanks to the social approval which attends the display of such behaviour, a large number of pathological manifestations in the field of religious behaviour remain unexposed. Another neurotic aspect of morbid religious behaviour is the other-worldly attitude of its devotees. This attitude will be found to be due, in a large number of cases, to the seductive influence of wishful thinking—the desire to escape from the stern realities of life. Such an individual, instead of redressing the wrongs of his society as he finds them here and now, clings fondly to certain illusory hopes which he expects to realize in the next world. This attitude of other-worldliness is not unlike certain forms of delusional insanity in which the patient ignores the world of real objects and lives in a dream-world of his own. Because of the uncritical attitude of society towards this mode of religious behaviour, a good deal of morbidity which masquerades under the garb of pious terminology, passes as a praiseworthy ideal of human conduct, and, in certain cases, is even a source of economic gain. Indeed the economic gains of certain religious institutions are so prolific that one is tempted to describe them in the words of E. B. Holt 'as strictly commercial enterprises as is a lottery, a soap factory or a pea-nut stand.' [1] This analysis of the religious behaviour of man could be profitably carried further, did the limits of time and space permit. But this brief discussion may serve to indicate that pseudo-religious behaviour, like the conventional ethics of our society is in urgent need of being rationally revised and adjusted to the real demands of the individual before humanity can hope to grow into rational and emotional maturity and, thereby, attain to health, sanity, efficiency and stability.

The efficacy with which the process of repression works in the life of the individual depends upon the subtle ways in which he is intimidated through the organized efforts of the various social institutions to whose influence he is constantly exposed. The repressive programme which begins in the earliest years of the growing infant makes use of all the horrors which are capable of frightening the child out of his wits. Parental disapproval,

[1] Holt, E. B.: 'The Whimsical Condition of Social Society and of Mankind', *American Philosophy Today and Tomorrow*, pp. 171–202.

the wrath of God, and the terrors of hell are a few examples out of a literally inexhaustible catalogue of institutional 'disciplines' which have been found efficacious in keeping the instinctual demands of the individual below the level of his conscious perception. Another result of this programme of repression is that these parental prohibitions and cultural taboos are gradually internalized in the shape of a conscience or super-ego whose chief function consists in plaguing individuals with self-reproach and a sense of guilt. This super-ego is now admittedly found to be the root-cause of a large number of mental disorders.

The internalized sense of social disapprobation and fear of consequent punishment, through the sheer force of the habitual docility of the individual, gradually degenerates into a mechanical or reflex function, so that the victim need have no conscious knowledge of its operation but may nevertheless be exposed to its painful consequences in the form of anxiety-neurosis or melancholia. Morbid fear and expectation of punishment is the invariable symptom of one's conflict with the super-ego. Very often the victim goes out of his way to punish himself. The various forms of the so-called accidental self-injuries or mutilations, in the last analysis, may be demonstrated to be the result of the unconscious sense of guilt and the demand for self-punishment. Indeed certain types of suicides and the event of recidivism could not be scientifically explained without the individual's unconscious sense of guilt and wish for self-castigation. In the light of such inexorable demands which it makes upon the already over-burdened individual the super-ego must be regarded as a neurotic stigma. A rational knowledge of its origin and nature would dispel the cloud of mystery which surrounds its compulsive character.

Two consequences of the conventional morality of our society appear to be most disastrous to the sanity and stability of man. (*a*) Repression which keeps the individual in a state of morbid ignorance with regard to the nature of his instinctual demands which in turn leads him to develop a state of smug and self-righteous satisfaction with our civilization. (*b*) The mental disorders or psychoneuroses which destroy one's happiness, sanity and efficiency through the operation of a rigid super-ego. This leads him to dissipate his creative ability in the various forms of neurotic manifestation. For, it must be clearly understood that repression of instinctual demands only renders one unconscious of their existence. In spite of the process of repression they carry on an underground existence and reveal themselves through certain bodily and psychical manifestations, generally known in the field of psychopathology as neurotic symptoms and disorders.

It must by now be abundantly clear how effectively the process of repression may dispel from the conscious knowledge of the individual the existence of his savage impulses. Let us

now turn to a brief discussion of its influence on the behaviour of young people within civilized society. One often hears of the perpetual restlessness and tension of the young men in our cultures. But if we lay aside the condemnatory attitude and view the situation objectively it will not be long before we discover the causal connection between this abnormal tension and the dictates of the conventional morality according to which they are expected to direct their lives. Viewed psychopathologically, anarchy revolt and antisocial behaviour of every description and variety are only blood-letting devices calculated to afford relief to their abnormal emotional tension. The following statement of an eminent English writer is exceedingly significant:—

'You can re-write the history of all the great population movements in terms of the pressure of the young male surplus . . . . . . Every community can be shown to be either sending out the plethora of its population as emigrants and settlers, or reducing it by warfare, or else suffering from acute social trouble, such social troubles as the words Russian Hooligans, Chinese Boxers, Moonlighters, Nazis, Fascists, revolutionary terrorists, gangsters, will call to mind. The young man surplus, if it is not consumed, is the main source of rebels, revolutionaries and disturbances of all kinds. Somehow that tension must find relief. The comparative social stability of the nineteenth century was largely due to emigration and the settlement of new lands. Now there are no more new lands open to immigration.' [1]

These words are all the more significant since they do not come from the pen of a professional psychologist. The writer has only recorded the fact of how young men in our culture are a perpetual menace to our social order. It is for us to correlate this fact with the extent of deprivation with which the instinctual demands of our young people are treated in our culture. Once again we have to thank the conventional ethics of our age for this sorry state of affairs. Its strategy of silence even where definite scientific knowledge concerning fundamental impulses of human nature is easily available, its deliberate distortion of such knowledge, its condemnatory attitude without any sympathetic insight into the state of the individual suffering from the strain of unsatisfied urges, the readiness with which it sacrifices the cause of truth and honesty by supporting falsehood and deceit in the service of its hoary conventions, its undisciplined idealism which has encouraged hypocrisy and self-complacent righteousness—all these have conspired to bring about the collapse of human intelligence and darken the destiny of mankind. It is high time that the exponents of this form of ethics should be made to realize the need of progressive

[1] Wells, H. G.: *The Fate of Homo Sapiens*, p. 42.

adaptation; and allow it to be tested by its results in a scientific spirit. The canons of right conduct must always take into account both the possibilities and the limitations of human nature.

The key to the social and political revolt of any country is to be found in the psychopathology of the young anarchist. Psychoanalytic study has demonstrated that oftener than not the leading social and political revolutionaries and anarchists have been recruited from the ranks of the victims of a deep unconscious hatred against parental authority. Their revolt against political authority was only a substitute reaction. Biographical studies of the leading anarchists often reveal significant familial situations which go to confirm the truth of this psychopathologic diagnosis. If all the facts concerning the parent-child relation from the biography of the great political revolutionaries and terrorists were to be made available to him, a psychoanalyst would undoubtedly be in a position to demonstrate that such individuals have been the victims of uncongenial family situations during their early childhood in which the male parent, unwittingly or otherwise, provoked the growing boy to harbour feelings of resentment and retaliation, feelings which he subsequently projects on to objects, which even in the remotest degree serve to remind him of the parental autocracy. Kings, government officials, teachers, priests have, it is known, often served as father surrogates who may bring out all the pent-up spite of the victim. Thus we see how an anarchist displaces his hatred for his father or father-substitutes on to social and political authority, and makes the world responsible for his unhappy childhood. A great deal of the antisocial behaviour of the individual is only the result of a displacement from the family to social maladjustment. At the bottom of many a political anarchy and unrest lies an emotional conflict between father and son. Generally the process is engineered by the unconscious forces of the victim's personality; and he often rationalizes his behaviour or simply treats it as an inexplicable mystery. It is only through the psychoanalytic technique that the ultimate cause of his trouble can be revealed to him.

V

The limits of this paper do not permit the examination of other aspects of human behaviour which present an equally sad picture of the present state and future prospects of the human race. The trend of the current events seems to indicate that mankind is steadily heading towards self-destruction. The only way of escape consists in the intelligent use of scientific Psychology in effecting the mental and emotional re-adjustment which appears to be incumbent on human society today. A society which has developed the use of scientific Psychology is already on its way to sanity and stability.

But it might be objected that every individual is gifted with a reasonable degree of common sense which enables him to make the necessary adjustment in his life without the help of sientific Psychology; and that since he can always learn wisdom from the errors of his predecessors, he need not invoke the help of scientific Psychology.

The objection fails to estimate the dimensions of the task which confronts mankind today. It is not only the conscious aspect of human behaviour which stands in urgent need of being scientifically understood and re-adjusted. The vast and unchartered field of one's unconscious motivation must also be clearly cognized and rationally re-oriented. Common sense without the help of psychological knowledge and technique is unable to meet the requirements of this complicated task.

The plea for learning from the errors of the past is an ancient one. Few, however, have benefited from this. For, even here the dimensions of the task have never been clearly estimated by those who have consistently endorsed the wisdom of this plea. It involves not only the avoidance of a specific pattern of overt behaviour but a scientific understanding of the motives which invariably produce it. No useful purpose, for instance, will be served in holding the isolated actions of Nero or Napolean as warning signals to the coming generation. What is really needed is the re-interpretation of their life and actions in the light of dynamic psychiatry, before men can be in a position to learn from their errors. We must be able to correlate the disastrous events in the regime of the past rulers and leaders of humanity with their neurotic and psychotic afflictions before we can rationally understand them and effectively avoid their recurrence. The same spirit of research must be carried into the records of certain other aspects of human behaviour. The psychopathological nature of fanaticism, puritanism, autocratic parenthood and pedagogy, for example, must be equally understood. It will be only then that the present generation will have a chance of avoiding the mistakes of the past.

But when we remind ourselves of the extraordinary advance which our age has witnessed in the scientific technique of diagnosing the latent contents of the human mind, the plea for preferring the lead of common sense appears to be even more absurd. This advance is mainly due to the scientific labours of Freud and his collaborators in the field of psychopathology and child psychology. To quote that brilliant British writer, H. G. Wells, 'Our knowledge of our own motives and impulses and then of mass-thought and mass-action, has become beyond comparison more lucid and practical, thanks primarily to the initiative of Freud'. Whatever the nature and extent of one's disagreement with this great scientist, one can hardly afford to ignore the extraordinary penetration with which he has captured the fleeting unconscious wishes and fears in their microscopic

detail for an objective scientific study and control. It would be only a superficial student of human nature who would prefer vague surmises of common sense to this penetrating insight into human maladjustments made possible through this new psychological advance. It is a wholesome sign that some of the leading sociologists are now beginning to recognize the need of psychological knowledge in the programme of social and political re-adjustment. Thus Karl Mannheim writes: 'If we want to change the human personality as a whole and not just its external behaviour, we must penetrate beyond the external behaviour to that realm of consciousness in which the different meanings of external acts can only be comprehended by sympathetic understanding. Thus we must try to pass from accessible surface-indices to the more deep-lying background of psychological phenomena ...... The discovery of the unconscious makes it possible to penetrate into those hidden mechanisms through which psychological adjustment on the deeper levels of the self can be brought about.' [1] Without the aid of scientific Psychology any attempt at mental diagnosis and re-orientation will prove only a planless dissipation of energy.

Let us briefly review certain ways in which scientific Psychology can help human society to readjust itself so as to secure its future stability.

In the first place, since, according to our analysis, the present crisis in the affairs of mankind is mainly due to the irrational restraints which society has come to exercise on the instinctual demands of the individual, it is of fundamental importance to correct our attitude towards these demands. The prevalent dread of certain fundamental urges of human nature is mainly determined by animistic beliefs still lurking in the unconscious depths of our personality. The ideal of ascetic deprivation of these urges seems to be mainly determined by such unconscious animistic beliefs. Psychological re-orientation will involve the realization of the fact that deprivation of any satisfaction, in itself, has no value to human health and sanity. On the contrary, needless deprivation of a fundamental urge has been found to be more harmful than beneficial to the health and sanity of the individual. We freely concede that there are occasions when the individual has to forego at least a temporary gratification of his instinctual demands. But this must be done as a measure of prudence and in consistency with the principle of enlightened self-interest, rather than through a superstitious dread of these urges. Fear will invariably lead to the repression of these and the accumulation of hatred, hostility and anxiety with which human society is at the present moment seething. Even when the need for temporary depriva-

[1] Mannheim, K.: *Man and Society*, p. 217.

tion seems to be indicated on grounds of social adjustment, it is important to sidetrack the instinctual demand in question into some adequate channel of expression so that the temporary suspension of gratification may not pass into complete deprivation. We are reaping today a rich harvest of deep-seated fears, hatreds, jealousies and anxieties which have been accumulating in the human mind on account of the needless deprivations of instinctual satisfactions to which individuals have been blindly subjected since the day of their birth.

In the second place, psychoanalytic treatment must be made more generally available than it is at the present moment. Whereas it may not result in a hundred per cent cure, it will still go a long distance in relieving individual distress and in ensuring the sanity of mankind through psychological control. I grant that emotional health of society can only emerge slowly in this way. But when it does emerge, it will have a greater chance to stay.

We must, however begin this work in the nursery. The psychological up-bringing of the child is the first step towards the mental health of the adult. The education of the child must be permeated through and through with the methods and principles of child psychology and mental hygiene. Unfortunately the current system of school education overemphasizes the purely intellectual nature of the child. The emotional aspect of his personality has not received the scientific attention which it demands. Consequently, one very often finds that a large number of individuals who pass through our existing educational mills, in spite of their intellectual development, remain emotionally immature. A great many maladjustments of the adult life are due to the continuance of emotional childhood beyond the normal period of its duration. We must deplore the lack of psychological insight of a large majority of those who bear the responsibility of educational leadership. This is further vitiated by the maladjusted teacher who is so overburdened with the heavy weight of his own emotional conflicts that one cannot reasonably expect him to guide his pupils along the lines of wholesome development of their personality. In the words of President Everett Dean Martin, '....... the teaching profession—with notable exceptions—tends to be filled with differential people, people who can trot in harness, conform to the system, take orders, and present controversial truths in an inoffensive manner. Teaching becomes a kind of trade similar in a way to other trades, with an average quality of workmanship and standardized quantity production of its object. People who all their professional lives must do just what they are told, commonly lose the habit—if ever it was of their organization—of judging the ultimate significance of that

which they are obliged to perform.'[1] A sound psychological training to prospective teachers is definitely indicated so that we may ensure the emotional health of the children entrusted to their care.

We must also urge the need of psychological clinics for children. For, in spite of the truth of the maxim that prevention is better than cure, and in spite of the supreme importance of adopting this maxim as the guiding principle at home and at school, there are nevertheless frequent occasions when even the most intelligent parents and teachers fail to know the neurotic-child-to-be when they see him. And even when they do know him it is very often at a time when the method of prevention is too tardy to operate effectively. There are several difficulties which prevent parents and teachers from clearly diagnosing and effectively treating the neurotic tendenies of their children. In the first place, a large number of neurotic symptoms of a child such as a pleasing docility, his speech difficulties, his eccentricities, his infantile ritualisms—instead of causing serious scientific concern about the child's normality, may please or amuse parents. In the second place, a large majority of those parents and teachers who do succeed in observing symptoms of neurotic behaviour in their children are liable to put them down to moral lapses and original sin. But by far the most urgent reason why we need psychological clinics for children is that owing to the peculiar nature of the tie which exists between parents and their children, there is always a limit beyond which no parent can guide a problem-child. May I add that not even an expert psychologist or a psychiatrist can help his own children beyond a certain limit. Take the case of a neurotic child. All that parents can do is to avoid those causes and conditions which may lead to the formation of neurosis in their children. This in itself is a colossal task. What they cannot do is to treat a neurosis *after* it has set in—particularly if *they* are the cause of it. There must be a psychical distance between the mentally sick child and the clinical expert, which distance, by the very nature of the case, is not possible between the parent and his child. Obviously, the only course open to parents, be they laymen or clinical experts, is to obtain clinical help from someone who has no peculiar ties of this nature with the patient in question.

Anna Freud, Melanie Klein, Margaret Lowenfeld, Susan Isaacs and others have brought an amazing psychoanalytic insight into the study of problem-children. Not only have they succeeded in accurately diagnosing the trouble of a large number of maladjusted children but have also brought health and

[1] Martin, E. D.: 'Education', *Whither Mankind*, 1928, edited by Charles A. Beard, pp. 355 ff.

happiness into their lives. Their scientific work must be followed up by others in different parts of the world.

The help of psychological clinics is specially needed in the treatment of cases of juvenile delinquency. The blind use of penal methods is not only unscientific, it is definitely barbarous. To quote from the writings of one of the foremost British authorities in the field of juvenile delinquency: 'To whip a boy, to shut him up in a penal institution, because he has infringed the law, is like sending a patient, on the first appearance of fever, out under the open sky to cool his skin and save others from infection. It is as blind and unintelligent as the primitive treatment of malaria, in the days when the parasite of malaria was unlooked for, and the mosquito ignored. With moral disorder as with physical we must find and fight, not symptoms, but causes. Not before causes have been discovered, can cures be advised.'[1] Someone has rightly observed that the attitude of society to crime is essentially animistic. Few advocates of corporal punishment realize how their use of this kind of discipline may be actuated by the unconscious animistic motive of driving the devil or the evil spirit out of the offender. Not only do we physically attack the person of the juvenile offender with the object of driving his devil out of him but very often our own devil which we project on to him. The mental condition of offenders is a problem which calls for careful study. Experimental projects in this field clearly indicate that delinquents may be amenable to psychological treatment. It is important, therefore, to make the services of a medical psychologist available to juvenile delinquents.

It is, however, from the view-point of prevention of subsequent maladjustments that the period of childhood has its peculiar importance for us. According to the findings of psychologists in the field of delinquency and neurotic illness, the various kinds of antisocial and emotional maladjustments have their inception during the period of early childhood. Whether we are dealing with a notorious criminal or a neurotic individual, we are eventually led to consider the causal connection of their trouble with certain conditions in their early infancy. It follows from this that the incident of individual and social maladjustments to a large extent may be prevented through a psychologically enlightened home. If the home ignores the resources of scientific psychology in the wholesome up-bringing of its children, subsequent institutional care of the mentally ill and the delinquent will never be able to keep pace with the progress of mental disease and crime. For, in spite of therapeutic efforts and institutional care in individual cases, the incident of pathological manifestation at any given moment, will far outnumber the cases of cure so long as the conditions of pathology are

[1] Burt, C.: *The Young Delinquent*, p. 5.

inherent in the very nature of the unfavourable home influences to which the child is constantly exposed. Under such circumstances increasingly more disorders will continually be produced than it would be possible for the curative agencies to tackle. The progress of disease will always keep steadily ahead of the therapeutic treatment. Total eradication of disease will thus remain absolutely outside the scope of human possibility.

It is, therefore, essential to realize the immense importance of parental education along the lines of scientific psychology as one of the most effective ways of ensuring the sanity of the coming generation. All actual and prospective parents must be educated in terms of the scientific facts and principles from the field of child psychology and mental hygiene. Nor should the value of the application of psychoanalysis to the profession of parenthood be ignored. There are subtle ways in which the personal neuroses of parents retard the normal growth of children. Certain causal factors in the psychology of problem-children very often may be traced to the emotional conflicts of parents. Psychological study of cases lends ample support to the statement that for every problem-child there is a problem-parent. Curiously enough, parenthood, one of the oldest human responsibilities, has not received the scientific consideration that it demands. A considerable amount of the scientific knowledge about the nature and development of the child is still a closed book for most parents. It must be clearly understood that the proper re-adjustment to life does not so much consist in what the scientists know, as in what the people apply.

It has been discovered invariably that a large number of neurotic and delinquent children come from unhappy homes. There may be a great many reasons to account for an unhappy home. But in the light of the findings of clinical psychology, we would emphasize the importance of a preliminary diagnosis of prospective marital companions in order to rule out at least one possible causal factor which is so likely to blight the life of the younger generation. A preliminary knowledge of the tastes and temperament of one's prospective marital companion is also essential for a harmonious home. Curiously enough whereas in the breeding of certain species of domestic animals greatest scientific care is exercised on the choice of a suitable mate in the interest of the health of the offspring, in the case of the human species this most important task is left to the caprice of the blind Cupid and his only too uncertain arrows. We also strongly endorse the opinion of Dr. Van De Velde according to whom little good for a healthy population is to be expected from marriages between those 'who are afflicted with mental disease, venereal disease, hypochondria, epilepsy, etc.'

Parents must, in particular, be enlightened about their obligation to their children in the field of sex-education. Through the irrational attitude and ignorance of their parents in this

field, many children grow into the belief that everything connected with sex is wrong and sinful. This in turn gives birth to a large number of personality disorders in their later life. Hysteria, anxiety neurosis, hypochondria, frigidity and impotence have often been observed to be the direct outcome of a morbid attitude towards sex which an individual acquired during his childhood. The conspiracy of silence with which parents meet children's questions regarding sexual knowledge, is the most prolific source of the sexual morbidity which prevails in modern society. A large number of sexual maladjustments which go to poison the marital life of individuals also have their roots in the subtle lies with which parents had attempted to discourage accurate knowledge on the part of their children. Curiously enough, whereas our children are encouraged to be up-to date in the field of science and art, they are kept perilously ignorant of this fundamental urge of their nature. In theory our educational experts admit readily enough that fearlessness and freedom are good for a child, and yet where sexual enlightenment is concerned they impose slavery and terror.

Sex education must be given in an atmosphere of scientific freedom and in a dispassionate attitude. It must be based on the most up-to-date findings in the field of sex psychology. Medical psychology has brought to light the fact that sex urge has its roots in the period of early childhood; and that a large number of neurotic disorders of the grown-up individuals within our culture are in the last analysis actual fixations at, or regressions to, certain infantile forms of sexual manifestations. By debarring our children from a healthy sex education, we expose them to all sorts of maladjustments. Whatever the amount of controversy on the subject, only a short-sighted parent will disregard Freud's warning that mental and personality disorders are, in the last analysis, traceable to sexual factors. In the light of these findings it follows that sex education must be given at an early age so as to ensure the healthy attitude of the coming generation.

It must, however, be noted that sexual education must be suited to the problems peculiar to the specific strategic level of one's psycho-sexual development. Sex education, therefore, cannot be a fixed, uniform course of knowledge irrespective of the specific needs of the growing individual. It must be a carefully graded scientific information suited to the psycho-sexual development of the individual concerned.

The basic task of psychological re-education involves a complete emancipation of the child from all the irrational fears with which he is surrounded. In this connection it must be recognized that if religion is to have a wholesome influence on the personality of the child, it must be purged of all those irrational threats which are likely to turn him into a coward and a hypocrite. It is mainly against this form of religion that

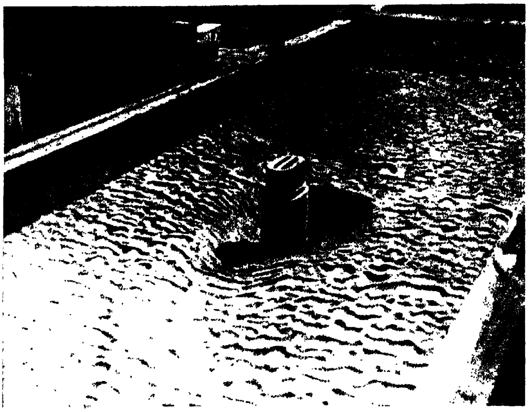
Freud's criticism may be interpreted as constituting a warning. The fundamental distinction between religion and pseudo-religion is one of attitude. Whereas the former consists in an attitude of courage, confidence and unselfish love, the latter involves an attitude of fear and infantile egocentricity. Nothing is more damaging to the sanity of the growing child than the influence of pseudo-religion. We strongly deprecate the condemnatory, negativistic attitude of the unenlightened priest who instead of infusing confidence and courage into the lives of individuals makes them the pitiable victims of abject terror and guilt. There is in the life-history of the child nothing so morbid as an exaggerated sense of guilt. This often leads to self-deceit and internal conflict, alien to the nature of the wholesome child, and forces morbid thinking and feeling which scar even the happiest disposition. Today mental hygiene considers this feeling of guilt in childhood as one of the most damaging happenings of early life, from which the child must be guarded as much as possible by those who minister to his needs.

Another way in which psychology will be found to have supreme value for the task of social re-orientation is the application of its scientific findings in the field of vocational selection. We do not refer to the application of vocational guidance and selection tests whose value is necessarily limited by their being largely confined to the exploration of the *conscious* aspects of one's vocational selection. In the light of the recent findings of psychoanalysis, the choice of an individual's vocation is very often determined by his unconscious motives. Dr. Wilhelm Stekel, for instance, has demonstrated how one's vocational choice may be determined by any of the five main motives working in the unconscious depths of his mental life. These are: identification with the father, hostility against the father, desire to sublimate, erotic and criminal impulses, defence or a protection against unconscious tendencies, and lastly, an unconscious sexual motive. These unconscious motives very often drive an individual to a choice of a profession in which, in spite of his spasmodic manifestations of enthusiasm, he often relapses into a sense of morbidity and inefficiency. In order to illustrate the various types within this classification, one may consider the case of the boisterous 'rough-neck' who may choose to become the manager of big electric works, a sadist who may choose the career of a surgeon, 'Jack the Ripper' who may develop into a gynecologist, an incendiary into a fireman, a foot fetishist who may choose the trade of a cobbler or may practice pedicure, and a man who is afraid of his criminal impulses may develop into a clamouring clergyman or a denouncing demagogue.

'But why not?' one may argue, 'Is not the individual, whatever his original unconscious motive, all the saner for having somehow transformed his dangerous impulses into a

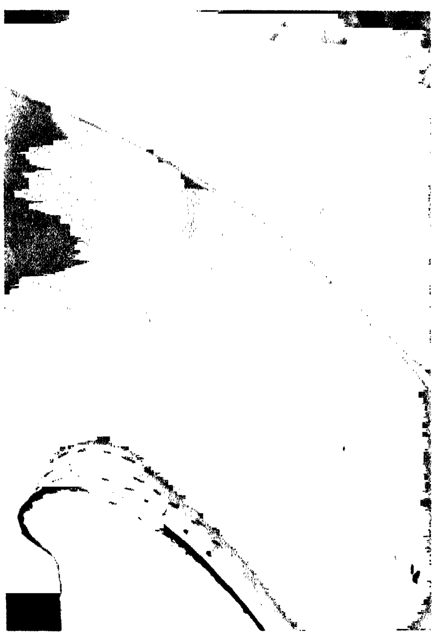
useful and socially acceptable vocation?' Decidedly not, we reply,—at least not so long as he is unconscious of the existence of these motives which carry on an underground activity within the subterranean depths of his personality. Not until he is enabled to have a psychological penetration into them can he be considered safe against their seductive influence. Like the delayed action explosives these dangerous motives bide their time; and may go off at any moment. Until he is liberated and re-oriented through psychological insight such an individual continues to be a social liability—a perpetual menace to the stability of the human race. We conclude that until psychoanalysis is pressed into the service of vocational guidance and selection, the most important aspect of this field will remain sadly neglected.

We have endeavoured to demonstrate from the various lines of evidence set forth in this paper that mankind has reached a critical point in its life-history where two alternatives irrevocably confront it: It must either seriously set about the task of emotional re-education and mental re-orientation towards problems of human life and experience or it must face the alternative of self-extermination. The second alternative is not the product of morbid fear. It is based on scientific evidence from the authentic records of the fate of certain species within the animal kingdom. Geological research has unfolded for us an amazing variety of fossils which show the ruthless extinction of whole species of animals who once dominated the earth but who in the course of evolution repeatedly failed to readjust themselves to the changing conditions of their environment. When we contemplate the obliteration of these mighty creatures, we tremble with deep concern for the future of mankind. For until a complete re-orientation is achieved within a short space of time, man bids fair to extinguish himself. The choice is irrevocable. There are only two alternatives: It is either re-education of man or the catastrophy of his cataclysmic extinction. This presents to Psychology its present task.



1410. Scour around a bridge pier model.
Looking upstream.

Separation of the nappe from the weir faces



2255. Showing separation of the nappe at side.
(Note the silk threads in the centre and at side.)

SECTION OF ENGINEERING

President:—C. C. Inglis, C.I.E., B.A., B.A.I., M.Inst.C.E., M.Am.Soc.C.E.

Presidential Address

(*Delivered on Jan. 7, 1941*)

HYDRODYNAMIC MODELS AS AN AID TO ENGINEERING SKILL

Introduction

There are few subjects concerning which so much confusion of thought exists as about the correct rôle of hydrodynamic models.

There is a marked tendency for Engineers either to hold that models give highly reliable results, or that they are untrustworthy, and must be viewed with grave suspicion.

The main reason for this confusion is due to hydrodynamic models being of several markedly different types, some giving highly accurate results, while others produce results which diverge widely from what occurs in the prototype; so that river conditions must first be translated to model equivalents and model results translated back to river equivalents.

The aim of this address is to clarify this question; not by mere statements, but by explaining the reasons why some experiments are highly reliable and have become little more than routine practice; while others depend almost entirely on field knowledge and correct diagnosis of field conditions.

Classification

In a previous Paper,[1] models were divided into 8 types; but it is now proposed to simplify the question by reducing the classification to 4 main types:

Type I. Geometrically similar models which give geometrically similar results.

,, II. Geometrically similar models which do not give geometrically similar results.

[1] 'The use of models for elucidating flow problems based on experience gained in carrying out model experiments, at the Hydrodynamic Research Station' by C. C. Inglis, *Proceedings of the National Institute of Sciences of India*, 1938.

Type III. Models with a mobile bed, in which 'flow pattern' is the dominant factor.

„ IV. Vertically-exaggerated models of rivers:

(*a*) rigid;
(*b*) semi-rigid;
(*c*) mobile.

TYPE I

Geometrically similar models which give similar results.

The reputation achieved by model experimentation has been built up mainly on models of Type I. In this category may be classed Rigid Models in which changes in energy relations between velocity and pressure is the chief factor, necessitating a similar Froude No. (V^2/gd) in model and prototype. This covers experiments to determine:

(*a*) coefficients of discharge,
(*b*) standing wave relations,

but fairly accurate results are also obtained as regards

(*c*) lines of flow at offtakes, and
(*d*) scour downstream of falls.

A host of successful experiments of this type will be found in the Annual and other Reports of the Poona Station and other Stations throughout the world; the results being highly accurate provided the model is not too small and roughness in the model is correctly adjusted or divergences allowed for.

A few examples of this type of model will be cited from recent annual reports:

I(a). (i) *Coefficient of discharge of Nira Left Bank Canal Head Regulator* [1]

Examples of Type I.

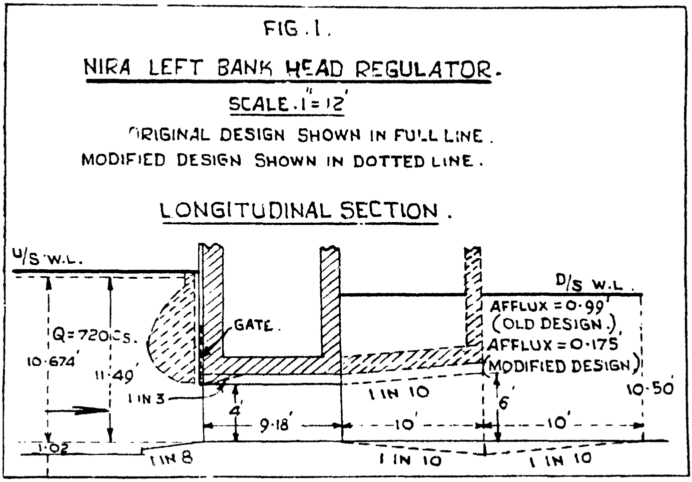
In this case the problem was to increase the discharge of an existing regulator, consisting of 7 spans of 4 ft., by 50%. By bell-mouthing upstream, and constructing an expansion downstream, the coefficient in the formula $Q = VA = AC\sqrt{2gh}$ was increased from 0·81 to 1·93, making it possible to increase the discharge with the same head 2·3 times, where

Q = discharge in cusecs,
V = mean velocity,
g = acceleration due to gravity, and
h = head = difference of W.L.s upstream and downstream.

[1] Bombay P.W.D. Technical Paper No. 54: 'Note on experiments with a model of the Head Sluices of the Nira Left Bank Canal.'

Figure 1 shows the original design (in full lines) and the modified design (in dotted lines).

The coefficients worked out from the model agree approximately with those obtained subsequently in the Canal.



I(a). (ii) *Determination of the variable coefficient of the* 10,569 *cusecs Tando Mastikhan Fall on the Rohri Canal, Sind*[1]

These experiments with a geometrically similar model have shown that the coefficient decreased with increase of depth and discharge due to impact losses at pier noses which necessarily increased with depth. The discharge formula of the Tando Mastikhan Fall in Sind was found to be

$$Q = C_1 (B - K\, n\, D)\, D^{1\cdot5}$$

where K = coefficient of contraction.
= 0·083 in Tando Mastikhan Fall.
n = number of piers = 9 in Tando Mastikhan Fall.
B = Waterway = 100 ft. do.
D = D_1 (Depth of water upstream over sill of flume) + $Va^2/50$.
C = a coefficient.

The accuracy of the results obtained in the model has been borne out by observations in the Canal.

[1] Annual Report of the Central Irrigation and Hydrodynamic Research Station, 1939-40.

I(b). Standing wave relations of the Tando Mastikhan Fall in Sind[1]

The standing wave relations in the Canal agree almost exactly with the model results.

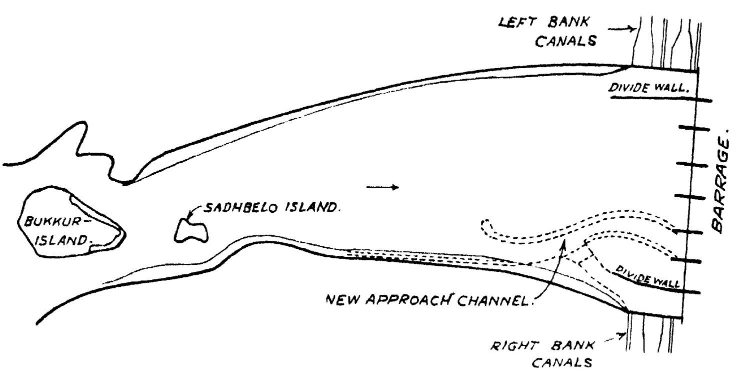
I(c). Design for entrance to right pocket from new approach channel at Sukkur[2]

Figure 2 shows plan of the Indus above the Sukkur Barrage with the new approach channel, designed to control the quantity of silt entering the Right Bank Canals.

FIG. 2.

PLAN SHOWING DESIGN OF NEW APPROACH CHANNEL, ALONG RIGHT BANK, TO EXCLUDE SILT FROM RIGHT BANK CANALS AT SUKKUR. (SHOWN DOTTED)

SCALE. 2 INCHES = 1 MILE.



The Right Bank Canals, in particular the North-Western Canal, draw excessive bed silt. As a result of model experiments

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[1] Bombay P.W.D. Technical Paper No. 44: 'Dissipation of energy below falls.'

(NOTE.—Instructions for design in Tech. Paper 44 superseded by those given in the Irrigation Research Division, Poona, Annual Report for 1934-35.)

[2] Annual Report of C.I. and H.R. Station, 1937-38 (pp. 26 and 27); 1938-39 (pp. 4 to 10); and 1939-40.

carried out 11 years ago [1] it was predicted that a silt bank would form along the right bank, and that the right bank canals would then silt. In the floods of 1936, the River carried an exceptionally heavy charge of bed silt, and the predicted sand bank formed along the right bank and heavy silting occurred in the North-West and Rice Canals. Various alternative methods of reducing the quantity of silt entering these canals were tested and the optimum design found was that of a curved approach channel 5,000 ft. long—shown in figure 2. This investigation presented many difficulties. Six different models with various scale ratios were used to determine the effect of different factors. To determine the best design of offtake from the Approach Channel to the pocket supplying water to the Right Bank Canals, a geometrically-similar, part-width, model was used and later the same model was used with increased depth to give a vertical exaggeration of 2 in the model as against a vertical exaggeration of 7 in the river model. This model showed that the width of entry could be made 35% less than shown by the river model with V.E. = 7.

I(d). Scour below flumed falls [2]

Reasons for scour below falls:

(1) Excess energy gives rise to eddies and surging flow.

(2) Instability of flow, due to expansion, causes 'heaving'.

(3) Too sharp divergences cause jetting, which sets up rotary flow and eddies.

- (i) The cheapest and best way to destroy excess energy in a glacis fall is to construct a baffle at such a level and height, and in such a position, as to destroy a maximum of energy.
- (ii) A deflector at the end of a pavement redistributes velocities and prevents scour downstream by causing a roller with a horizontal axis to form.
- (iii) Permissible divergence decreases slightly with increase of discharge.
- (iv) Diverging vanes in continuation of piers fan out flow successfully if correctly designed.

The Tando Mastikhan Fall was constructed with side expansion too sharp, viz. 1 in 5 against 1 in 10 required. Vanes to fan out the flow were therefore added. The fall, with these modifications, is operating very efficiently and bears out all the conclusions drawn from the model. Subsequent experiments have shown that a high fluming ratio necessitates longer

[1] Bombay P.W.D. Technical Paper Nos. 45, 46 and 52.

[2] Bombay P.W.D. Technical Paper No. 44, and also Annual Report of the Central Irrigation and H.R. Station for 1939-40.

expansions to obtain suitable downstream conditions, and that falls should be designed to work satisfactorily even though 25% retrogression occurs; because some designs fail under such conditions.

A border-line case between Classes I and II is a siphon spillway. It comes under Class I for fully primed coefficients; but gives different results for priming depths.[1]

Type II

Geometrically similar models which do not give similar results.

Under Type II may be cited some recent experiments carried out at Poona:—

(i) Coefficients of High-coefficient Weirs.[2]
(ii) Slab movement in submersible bridges.[3]

(i) In the case of High-coefficient Weirs, in which the curvature of the profile of the Weir is sharper than the path which filaments of water would follow if discharging freely into air, the coefficient of discharge in the formula $q = c\ D^{1 \cdot 5}$, where q = discharge per foot run and D = upstream depth over weir, increases both with depth of water over the weir and scale. The former is due to the fact that as Q increases, the natural path of flow under aerated conditions diverges more and more from the curvature of the weir and hence, so long as the water adheres to the weir profile, a reduction of pressure occurs; and as

$$p/w + V^2/2g + Z = \text{constant}$$

for a filament (Bernoulli's theorem) the velocity is correspondingly increased and also the discharge.

An increase in scale also causes an increase in scalar discharge; because whereas pressure is constant when the water discharges freely into air, the reduction of pressure increases with scale, and hence the velocity and Q also increase.

It was not possible to estimate the discharge in the prototype, theoretically, and so a series of models of different scales were constructed and results extrapolated to give conditions in the prototype as regards pressure and discharge.[4]

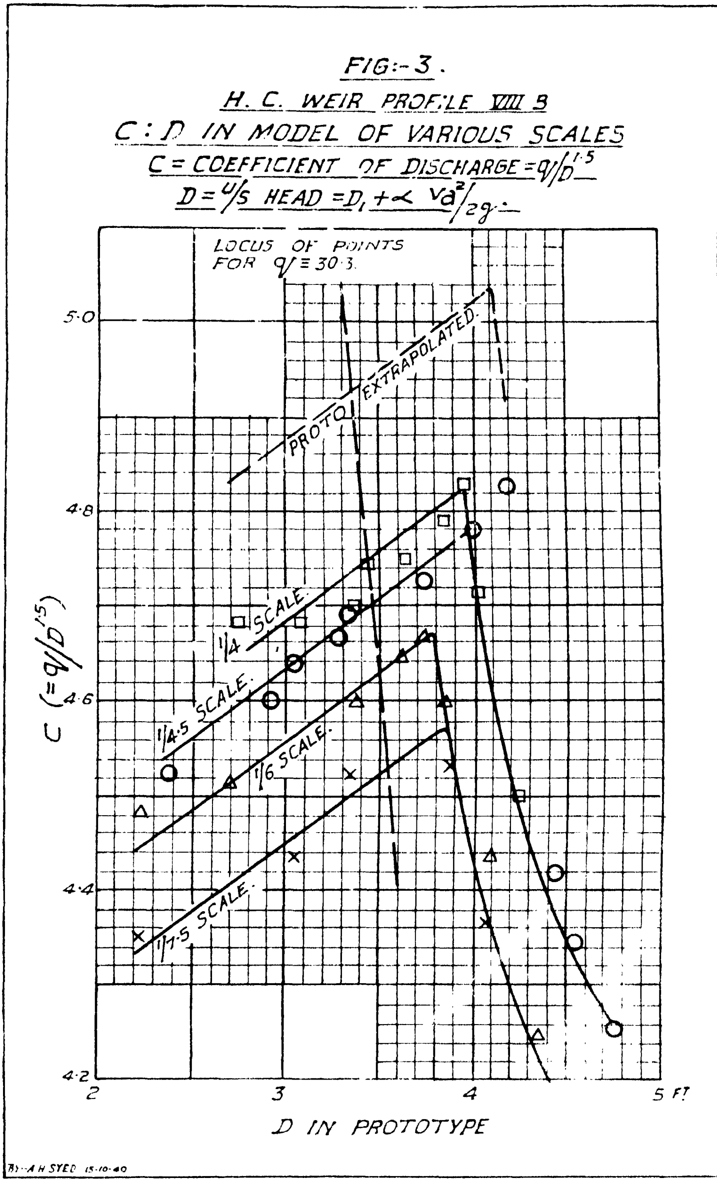
Figure 3 shows the coefficients obtained in models with scales: 1/4, 1/4·5, 1/6 and 1/7·5 of the prototype. From this it will be seen that the larger the scale, the higher the coefficient.

[1] Annual Report of the Central Irrigation and Hydrodynamic Research Station for 1939-40.

[2] Annual Report of the Central Irrigation and Hydrodynamic Research Station for 1937-38, pp. 39 to 44 and 1939-40.

[3] Annual Report of the Central Irrigation and Hydrodynamic Research Station for 1938-39, pp. 31 to 37; and Annual Report, 1939-40.

[4] Annual Report of the Central Irrigation and Hydrodynamic Research Station for 1937-38, pp. 39 to 44 and 1939-40.



When these coefficients were extrapolated, the conclusion arrived at was that the coefficient in the prototype with $D = 3{\cdot}35$ and $q = 30{\cdot}3$ cusecs would be 4·93 compared with 4·75, 4·7, 4·63 and 4·53 in the various scale models.

In this particular case, as a result of constructing a new 200 cusec channel, we are now in a better position to check up the accuracy of the conclusions hitherto arrived at by extrapolation from small models to full scale; but even this has presented difficulties; because whereas the weir at Bhandardara is 650 ft. long, it is only 4 ft. in the model; so that the effect of the side boundaries, which is negligible in the prototype, is considerable in the full scale model; so has to be allowed for.

The method adopted after small scale trials was to draw the flow into the 4 ft. channel containing the model, through a bell-mouth from a wider channel. This had the effect of regularizing velocities across the 4 ft. channel.

It was necessary, however, to place the model sufficiently far downstream of the bell-mouth for the flow approaching the weir to be sensibly parallel. As a result of this, slight boundary layer effect was present. A further difficulty arose at the weir itself due to retardation of the high velocity flow at the sides. The effect of this was partially corrected by providing a very small degree of expansion in the side-walls, but the effect on the pressures remained, causing slight inward flow at the crest, relieving the negative pressures and so reducing the discharge coefficient. This inward flow can be clearly seen in Photo No. 2255 (preceding the Address) in which threads, fixed on the weir, show distorted lines of flow.

Figure 4 shows the coefficients of discharge in the formula $V = C\sqrt{2g\ D}$ plotted against depths D in the full scale model.

It will be noticed that the coefficient instead of rising to a clear-cut maximum as in figure 3, rises on a curve, and before reaching its natural maximum, falls to meet the rapidly falling line at $C = 4{\cdot}70$. Dotted lines show the rising and falling curves extrapolated. These meet at $C = 4{\cdot}9$ with $D = 3{\cdot}35$ ft., as compared with 4·93 extrapolated from small scale models (*vide* figure 3); but whereas by that method the maximum value of C rose to 5·03 with $D = 4{\cdot}10$, this has not been attained in the part-width, full-scale, model, due to side effect.

(ii) *Slab movement in submersible bridges* [1]

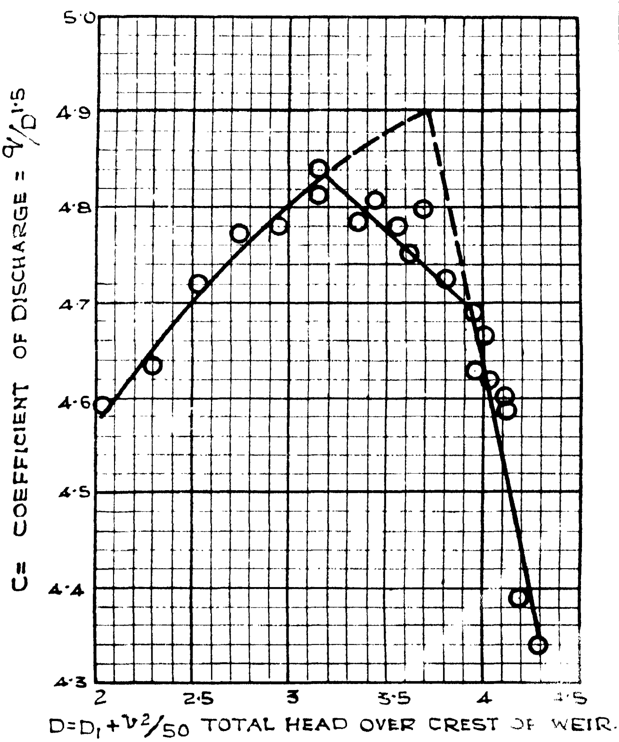
In this series of experiments, though impact effects were accurately reproduced, yet slabs of specific gravity equal to that in the prototype did not move in the model, though this had happened in rivers in the Central Provinces. Indeed the model slabs did not move in a 1/12 model with $V = 2{\cdot}5$ ft./sec. (equivalent to 8·5 ft./sec. in the river) even though the weight of the slab was reduced from 46 lbs. to 31 lbs., corresponding

[1] Annual Report of the Central Irrigation and Hydrodynamic Research Station for 1938-39, pp. 31 to 35.

weights in water being 27 lbs. and 12 lbs. respectively; so that the relative weight in water was only 44% of the equivalent weight in the prototype.

FIG. 4.

SHOWING C:D CURVE FOR FULL SCALE MODEL OF H.C. WEIR 4 FEET WIDE.



This investigation showed that the washing away of unanchored bridge slabs was due to vibrations set up by rapid changes of pressure induced as a result of the high Reynold's No. in the river; and it was shown that the larger the model the higher the specific gravity of the slab which was just washed away with the same relative discharge.

The model showed that movement was so gradual as to be scarcely visible except over appreciable periods of time, and was probably discontinuous; but eventually the slab moved downstream on its pier supports until about half the slab overhung, when it tipped up and was carried downstream. In this case, extrapolation could not be resorted to in order to determine the weight of prototype slab which would just not move; because the scatter in different observations in the model was of the same order of magnitude as the effect to be determined. This did not matter from the practical standpoint; because the Station was asked how to stop this occurring and the obvious solution was to anchor the slabs or provide stops to prevent the slabs moving downstream on their pier supports.[1]

Type III

Mobile models in which flow pattern is dominant factor.

A good example of a model with a mobile bed in which 'flow pattern' is the dominant factor is the conditions of flow which exist round a bridge pier constructed in erodible sand.[2]

It is shown in the 1938-39 Report that scour at pier noses is due to the oncoming water, which is deflected by the pier, diving downwards towards the upstream toe of the pier before sweeping outwards on either side of the pier—see photo 1410 at the beginning of this Address. This action is due to the 'flow pattern' and is scarcely at all affected by the upstream bed level, which, in turn, is determined by the sand of the river bed; so that, whereas the depth of actual bed upstream of the pier is $\propto q^{\cdot 71}$, the depth of scour at the toe of the pier $= 1{\cdot}7 b^{1/4} q_c{}^{1/2}$,

where q = maximum discharge per ft. width,
d_s = scour depth at nose of piers,
b = width of pier, and
q_c = discharge per ft. width some distance upstream of pier.

The latest experiments show, however, that when a pier is protected by stone, the depth upstream has an effect on the discharge which causes failure, the stone failing with a smaller discharge when the bed level is higher—i.e. when the bed material is coarse.

Although scour at a pier, and to a lesser extent at spurs, can be estimated roughly from formulae and applied to specific cases of rivers, yet complications arise in river models which are naturally vertically exaggerated. This will be dealt with later, as it falls under both Types III and IV.

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1 Annual Report of the Central Irrigation and Hydrodynamic Research Station for 1938-39, pp. 31 to 35 and 1939-40.

2 *Ibid.*, pp. 39–41 and 1939-40.

Type IV

Vertically-exaggerated models of rivers:

(*a*) Rigid,
(*b*) semi-rigid,
(*c*) mobile channels.

IV(a). Rigid vertically-exaggerated models

In such cases, the usual practice is to fix a suitable vertical-exaggeration, estimate the mean roughness required, and then verify slopes for known discharges. If the slope is in error, the roughness is altered until it becomes satisfactory. This is a slow process; because changes made in one part of the model affect other parts. Then again, though the model may give satisfactory results with one discharge, it may give unsatisfactory results with a larger or smaller discharge; and a uniform roughening will not give correct results. A large amount of data and much patient 'trial and error' work is therefore necessary which, experience in America shows, may have to be spread over a period as long as two years. After such verification, it is assumed that correct levels will be obtained for conditions outside the verified range—as for instance in a flood of greater magnitude than previously observed or when different slopes and local intensities of flow occur, due to peak floods in tributary streams reaching the main stream at different times from those of previous recorded floods. Such models can undoubtedly give most valuable information as regards flood levels, lines of flow, and points where violent action will occur under such conditions; but the model, being rigid, cannot give direct information about scour, which must be inferred by the experimenter, nor will the flow for such conditions be correct; because in nature, heavy scour would cause marked changes in conditions.

Rigid models have been used to a large extent at the U.S. Waterways Experiment Station at Vicksburg in connection with tidal model studies. In many of these, coal dust and other still lighter materials have been injected to indicate the movement of sediment and the amount of sediment likely to deposit in various positions, marked out on the bed of the model by white-bordered squares, has been measured by sucking the deposited material through a vacuum cleaner type of machine, the material then being separated by a machine resembling a cream separater. The difficulties to be overcome in such models are very great, and the data required for successful verification enormous, it being considered desirable to have detailed data for a period of 5 years.

A rigid model of a 20 mile length of the Hooghly above Calcutta has been constructed at Poona to determine lines of flow and points where bed action is severe under various

conditions of river and tidal flow. It is the intention to use this information subsequently, in semi-rigid or mobile part-models, to investigate the specific bank-scour problem, using much larger discharges.

IV(b). Semi-rigid

In semi-rigid models the sides, and in some cases large parts of the bed, are held. This, by making it practicable to enforce a vertical exaggeration in excess of what is natural, makes it possible, while retaining the same Froude Number as in the prototype, to increase the slope, and hence the silt charge.

This makes it possible to reproduce similarity much more accurately than is possible in a fully-mobile model and so simplifies interpretation. On the other hand, it imposes conditions throughout the length of the model, and the model cannot scour its banks, which are rigid, nor change its course; and if, as is generally the case in India, the question we desire to investigate is 'future changes of river course and the secondary effects of such changes', we must, when using models in which the sides are held, predict the changes and the rate of those changes, to enable us to determine the secondary effects which will result from those changes.

An excellent example of a case in which this was done is the Rangoon model.[1]

In that case the model was bounded by a curved wall dividing the assumed tidal flow affecting the model problem, from the tidal flow to the East; and the right bank of the River was cut away from time to time at a rate assumed by the experimenter, based on judgment. Working on these two assumptions, it was found that while the Port was not threatened by eventual extinction, it was evident that some limitation on the draught of vessels using the Port would be inevitable unless rectification of the approaches was carried out by artificial means—a prediction which, it is understood, has been fulfilled. The point I wish to emphasize here is that the correct result obtained in this model was due to the skill of the experimenter in making correct assumptions, and had he made incorrect assumptions he would have got wrong results.

IV(c). Mobile channels

In this section it is intended to work up from the simple to the complex. The simplest case of a mobile channel is one in which the discharge and silt charge are constant.

[1] Institute of Civil Engineers, Paper No. 5100: 'Investigation of outer approach channels to the Port of Rangoon by means of a tidal model' by Oscar Elsdon.

Lindley in 1919 put forward the original theory that 'the dimensions, width, depth and gradient of a channel to carry a given supply loaded with a given silt charge were all fixed by nature'.[1]

Nine years later, Gerald Lacey produced a series of formulae which fixed gradient and dimensions of channels.[2]

Recently, Lacey has set forth his theory as developed up to July 1939 [3]

His formulae, re-stated in terms of the two independent variables Q and f—discharge and silt factor—are as below:

$$
\begin{aligned}
P &= 2{\cdot}667\ Q^{1/2}\\
R &= 0{\cdot}472\ (Q/f)^{1/3}\\
V &= 1{\cdot}1547\sqrt{fR} = 0{\cdot}7937\ Q^{1/6}f^{1/3}\\
S &= 0{\cdot}000542\ f^{5/3}/Q^{1/6}
\end{aligned}
$$

where P = wetted perimeter; R = hydraulic mean depth; V = velocity and S = slope.

These may be compared with the corresponding formulae subsequently worked out by Dr. Bose of the Punjab Irrigation Research Institute in 1937, which were evolved by statistical methods from a mass of regime channel data collected over a period of 5 years in the Punjab:[4]

$$
\begin{aligned}
P &= 2{\cdot}8\ Q^{1/2}\\
R &= 0{\cdot}47\ Q^{1/3}\\
V &= 1{\cdot}12\ R^{1/2} = {\cdot}767\ Q^{1/6}\\
S &= 0{\cdot}00209\ m^{\cdot 86}/Q^{\cdot 21}
\end{aligned}
$$

where m = Mean diameter of silt.

Accepting the Lacey and Bose formulae as being very approximately correct for regime conditions, we find that whereas P, the wetted perimeter, varies as $Q^{1/2}$; R, the hydraulic mean depth, varies as $Q^{1/3}$, and hence R/P, the shape, varies as $1/Q^{1/6}$; which means, in model terminology, that vertical exaggeration (= hydraulic depth $\div$ hydraulic width) varies inversely as the 1/6th power of the discharge, the channel shape being relatively deeper in small than large channels. It will be noted that in the Lacey slope formulae, the slope for the same silt factor also varies inversely as $Q^{1/6}$; and hence, according to the Lacey formulae, slope exaggeration is equal to vertical exaggeration for the same silt in model and prototype; but, whereas the silt

[1] 'Regime Channels' published in *Proc. Punjab Engineering Congress*, Vol. VII, 1919.

[2] 'Stable channels in alluvium' by Gerald Lacey, *Proc. Inst. C.E.*, Vol. 229, 1929-30.

[3] 'Regime channels in incoherent alluvium,' Central Board of Irrigation, Publication No. 20 of 1940.

[4] Punjab Irrigation Research Institute Reports for the year ending April 1937 and April 1938.

factor 'f' enters 'vertical exaggeration' (which refers essentially to the cross-section of a stream) in the form

$$V.E. = R/P \propto (Q/f)^{1/3} \div Q^{1/2}, \text{ or } 1/f^{1/3}Q^{1/6},$$

slope exaggeration enters in the form $S.E. = f^{5/3}/Q^{1/6}$; that is to say, whereas a coarser silt increases the $S.E.$, it decreases the $V.E.$ and the ratio $S.E./V.E.$ varies as $f^{5/3+1/3} \propto f^2$. From the sensitiveness of this relation it will be clear how important it is to choose correct silt conditions in a model.

For these and other reasons, channels can be designed much more accurately by the use of formulae than by model studies, and hence models are not required, nor would they be useful for designing ordinary channels, though they are very useful when the problem is to ascertain why unnatural conditions arise in the vicinity of masonry works, bends, or changes of material of sides or bed.

Lacey Limiting Velocity

Inherent in the Lacey formulae there is a limiting velocity. Lacey has assumed that the natural shape of a silt-bearing channel in incoherent alluvium is an ellipse, and hence the limiting section is a semi-circle, so

$$P/R = 2\pi = 6{\cdot}283$$

and as

$$\begin{aligned} P^2 &= (2{\cdot}67)^2 Q = 7{\cdot}12\ PRV \\ P/R &= 7{\cdot}12\ V = 6{\cdot}283 \\ \text{or } V_{\text{lim}} &= 0{\cdot}882 \text{ ft. per second.} \end{aligned}$$

If, however, $P = 2{\cdot}8\sqrt{Q}$ (Dr. Bose's formulae, derived from Punjab data) then $P/R = 7{\cdot}84\ V$ or $V_{\text{lim}} = 0{\cdot}8$; and if $P = 3{\cdot}2\sqrt{Q}$, our Station formula for a certain range of discharge and types of silt, $V_{\text{lim}} = 0{\cdot}62$. While it must be admitted that the assumption that a semi-circle is the limiting shape of a channel is, at best, only an approximation; yet, if even approximately correct, it leads to the conclusion that in natural silt-bearing channels carrying small discharges, a change of law must occur when the discharge reaches a certain low discharge. This change of law would be sudden according to the Lacey formulae, but is more likely to be a gradual transition in practice, taking into consideration the known gradual decrease of silt movement with reduction of discharge. Eventually silt movement must cease and the law must then be different. It was found at Poona in 1937, on plotting available data, that silt charge varied approximately as $(V - V_{rt})$, where V is the actual velocity and V_{rt} is what we have called the 'regime threshold velocity', which, for practical purposes, is the same as

'competent velocity', a term used in America for the velocity at which silt movement just commences.[1]

It has been found that the velocity at which silt movement ceases in shallow channels is little affected by depth; but, unlike in the Lacey theory, it depends on grain size, varying approximately as $V_{rt} \propto m^{1/3}$.

With the sands normally used at the Poona Station, V_{rt} varies between 0·7 to 1·0 ft./sec.

From this, it follows that silt movement, always relatively much less in a natural mobile model than in its prototype, will start in a river with a relatively low discharge and will continue until the discharge again finally falls to this same low value; whereas in a model, with a flood velocity of say 1·25 ft./sec., silt movement will not begin until the discharge is equivalent to about half the flood discharge.

As long ago as 1929, A. H. Gibson in his Report on the Severn,[2] concluded that the best results were obtained with a silt which was 20% finer than in the prototype and the use of a somewhat finer silt in models is almost certainly desirable.

That this is likely to be so, follows from Lacey's latest theory[3]: that for a given degree of agitation the silt charge varies inversely as the terminal velocity of silt falling through water (V_s), which in turn varies approximately as m (where m, the mean diameter of bed silt particles, is of the order 0·2 to 0·5 mm.), the relation being $m = 0{\cdot}0645\ V_s + 0{\cdot}042$.

This theory was based on an analysis of a paper by Dr. C. M. White entitled 'The influence of transported solids upon Rivers'.[4]

The correctness of the theory has already been shown by the Poona Station both for very heavy silt charges[5] and normal silt charges.[6] Though this relation enables us to increase the silt charge by reducing the grade, it has little effect on the velocity at which silt movement begins and ends; so does not eliminate our main difficulty.

[1] Studies in Engineering, University of Iowa, Bulletin 5: 'The transportation of detritus by flowing water—I.' By F. Theodore Mavis Chitty Ho and Yun-Cheng Tu.

[2] 'Construction and Operation of Severn Tidal Model' by Prof. A. H. Gibson—Paper written for Economic Advisory Council, Severn Barrage Committee.

[3] Note on Dr. White's theory of 'Silt Transport' by G. Lacey, dated 13th December 1939.

[4] Read by Dr. White (City and Guilds, London) to the Potomological Section of the International Union of Geodesy and Geophysics at Washington, D.C., U.S.A., in September 1939.

[5] C.I. and H.R. Station Interim Basic Note No. 50, dated July 1940: 'Rate of deposition of silt as governed by silt charge and terminal velocity.'

[6] C.I. and H.R. Station, Supplementary Basic Note No. 50, on the same subject—with natural silt charge.

EFFECT OF A LIMITING VELOCITY

The effect of this limitation is not important in those relations in which action takes place at maximum discharge, so does not appreciably vitiate results as regards limits of embayment, as shown in the Hardinge Bridge experiments.[1] In this, it was shown that had free embayment been allowed to occur upstream of the Right Guide Bank of the Hardinge Bridge no damage would have resulted; whereas by constructing the Damukdia Guide Bank across the natural line of flow, natural embayment had been prevented, which had led to an increase of action at the Right Guide Bank, and consequently had been an important factor contributing to its failure.

In a large proportion of river problems, however, the scour which occurs during falling floods is a very important factor in determining flow conditions the following year, and this is not reproduced correctly in natural models.

The alternatives to meet this situation are to depend mainly on experience and judgment or else to distort the model scales to increase silt movement with low discharges.

METHODS TO REDUCE EFFECT OF LIMITATION OF SILT MOVEMENT

Two methods have been followed at Poona to increase silt movement in the model for conditions corresponding with low river discharges:

(*a*) low discharges have been scaled up, and
(*b*) slope has been exaggerated.

To deal with this question adequately would require a separate paper. Suffice it to say here, that in general, the first method gives valuable information over part of the model but does not give correct results over the whole of the model. An example of this is the 1/300 scale model of the Sukkur Barrage from which we have obtained similarity of bed contours and flow along the right bank, which was the problem we were investigating; but conditions on the left bank were not correctly reproduced which, in this particular experiment, did not matter.

REDUCED SILT MOVEMENT IN MODELS

Although it is a digression, it seems advisable, at this point, to touch on the question of 'silt deposition'.

In a river, by far the greater part of the silt in motion is normally in suspension, whereas in models the proportion of

[1] Bombay P.W.D. Technical Paper No. 56 entitled 'Report on experiments with models in connection with the protection of the Hardinge Bridge on the Eastern Bengal Railway'.

silt in suspension is relatively small. For this reason, not merely is the silt movement much less in the model; but the silt which deposits in the river—namely fine suspended silt—forms a relatively small part of the model silt charge. The reproduction of full natural silting in the model is therefore well-nigh impossible even if the time scale be based on silt charge—i.e. on $(V - V_{cr})$—which would lead to the time scale being greatly increased as the silt charge decreased with smaller discharges.

This is not quite so bad as it sounds; because scour starts later in the model and is relatively less than in the river; in other words, just as silt movement in the model is relatively much less, so also is the amount of annual scouring and silting. Should this fact be overlooked and the model bed be laid according to cold weather conditions in the river, scour pits at the noses of groynes or obstructions would contain more silt than would be natural in the model; and this excess, when scoured, would produce unnatural sand banks in the model.

An extreme example of reduced silt movement in a model is afforded by the 1/300 Sukkur Barrage model in which, if the model is regulated as at the Barrage, silt movement does not begin till the discharge exceeds half the normal maximum flood discharge.

Slope Exaggeration

Coming now to the second method of inducing early scour, i.e. slope exaggeration: This necessitates a smaller vertical exaggeration and hence, in effect, distorts the model. This method may be very useful in a short model provided entry conditions are correctly imposed, but is not suitable for long models. Before dealing with the relative merits of long and short models the question of distortion requires further consideration.

Effect of Exaggeration of Banks and Rigid Structures

In most Stations it is the practice to exaggerate bank slopes and rigid structure according to the depth exaggeration scale; because otherwise they would occupy a disproportionate width of the model, and the deeper the scour, the greater would be the projection of the toe of a groyne or other rigid structure. This does not, however, produce correct results in the model; because owing to the 'flow pattern' being approximately similar in the model and prototype, while the depth is relatively much greater in the model, the width of bed action is relatively much greater in the model—as already explained in para 10—; and where, as in the case of scour at the nose of the new approach channel at Sukkur, the scour pit is very deep relative to the

width of the channel, the width of the scour pit in the model, the slopes of which are determined, as in the river, by the angle of repose of the material, extends right across the approach channel.

In addition to this, (but in this case reducing the error) the depth scale of the scour pit is different from the scale of the river part of the model, depending—as explained in para 10—on a different law, and as steep banks exceed the angle of repose of all except rigid materials, natural bank scour is precluded. In practice, therefore, the choice lies between rigid, steep, sides, and mobile, and hence relatively flat, slopes which take up much too great a width of the model.

In some models, and in some parts of most models, bank action is comparatively unimportant; but in many cases this is a very important factor and the limitations can only be partly overcome by the use of large-scale part-models.

Throw-off

'Throw-off,' by which is meant the angle of deflection of the filaments, is also distorted in vertically-exaggerated models, and to get approximate similarity of 'throw-off', the slope of the rigid structure has to be considerably less vertical at its upper end than according to that due to the vertical scale-exaggeration of the model.

Longitudinal Distortion

Finally, we come to longitudinal distortion: Vertical exaggeration is essentially a latitudinal exaggeration, just as slope exaggeration is essentially a longitudinal exaggeration; but in model studies, even when the slope exaggeration is increased by tilting the model, to increase slope and velocity, the longitudinal scale is almost universally made the same as the latitudinal scale. This is done in order to prevent distortion in plan. This means that both rigid and non-rigid parts of all vertically-exaggerated models are distorted: That is to say, they are foreshortened longitudinally in the ratio of the vertical exaggeration.

In extreme cases this would lead to sub-critical conditions in the river being converted into hyper-critical velocities in the model; but more generally it leads to distortion due to the length in which changes have to take place being foreshortened. Thus the length in which new lines of flow or eddy-patterns have to become established in the model as a result of changes of section or roughness is inadequate in the model to establish the change before a further alteration in the angle of flow or roughness occurs.

Two good examples of this are flow from the twin gorges at Sukkur[1] and the groynes in the Jumna at Delhi.[2] In the former, the gorge is foreshortened 7½ times, affecting both lines of flow and eddy pattern of the water leaving the gorge, while in the latter case the groynes were seven times closer together relative to depth than in the river.

LONG AND SHORT MOBILE MODELS

The advantage of a long model is that curvature of flow and silt distribution are more natural, and so the river is more free to swing or change its course. Meander condition,[3] on which the solution of a large proportion of river problems ultimately depends, are also more accurately reproduced. On the other hand, less distortion of slope and discharge is permissible to obtain increased silt movement; and cost of collecting data, verification, and carrying out experiments is very much greater. In addition, the likelihood of omitting some important substratum—such as layers of clay, kankar, etc.—is proportionately increased; and finally, no matter how long the model may be, entry conditions, on which changes in a meandering river largely depend, and to a smaller extent, exit conditions, must be correctly imposed.

In a relatively short river model, much greater control is possible and much more silt can be kept in motion than in a longer model; but the results also depend to a much greater extent on the accuracy of the conditions imposed at entry—i.e. the distribution of silt and curvature of flow of the water. To impose these correctly is always difficult, necessitating a deep understanding of field conditions, which must be accurately diagnosed and completely visualized before their effects can be correctly imposed. Obviously those who can diagnose upstream conditions can also foresee, with equal accuracy, what the model portion of the river will do; hence the skilled experimenter knows very approximately what result the model should give when he is designing it and before he carries out experiments. The main function of river models, therefore, is to check up results with the experimenter's ideas, improve on them, and then fill in details. It is only in the simplest cases, which scarcely require model verification, that a single model will suffice. In most cases, as for instance, experiments in connection with controlling silt entry into the Right Bank Canals above the

[1] Annual Report of C.I. and H.R. Station, 1939-40.

[2] *Ibid.*

[3] Programme of Proceedings, 11th Annual Report of the Central Board of Irrigation, India, 1940. 'Factors controlling meandering' by C. C. Inglis, pp. 94–109.

Sukkur Barrage,[1] we have had to use several different models—6 in that case—varying from geometrical similarity to vertical exaggeration of 7½.

Conclusions regarding Scope and Limitations of Mobile Models

The impression I may have created is that river models cannot be expected to give useful information. That, emphatically, is not my view; but any idea that all you have to do is to construct a vertically-exaggerated scale-model of a river and that it will give the correct answer is nonsense.

I will quote a few cases which will clarify this point:

(1) 'We were asked to advise on how to control the main channe along the left bank of the Sarda River above Banbassa Weir. In the course of the early experiments, though the model did not indicate it, the conviction grew that the river would swing and burst through the central island. Subsequently, a very close inspection of the river confirmed this belief, which was not shared by the local officers. This was of importance; because, in the event of this happening, the work required would then be modified. In spite of a stone bank being built to prevent such a spill channel forming and to direct flow into a central, existing, channel, the stone was swept aside and a spill channel formed which carried 30% of the river discharge in the first year.'

(2) 'We were asked to design a fall required to check very severe scour which had been occurring in a nala.

The data supplied, and design proposed, showed a steep gradient and hypercritical velocities. Previous experiments carried out at another Station, with a lined, geometrically-similar model, had given similar flow conditions to those shown in the designs.

Before experiments were started at Poona, it was concluded that such conditions could not persist and that either the banks would scour, causing intermittent shooting flow and standing waves, or else the bed would scour, flattening the slope until subcritical velocities resulted. The practical effect of this was that a depth of 14 ft. of water was to be expected above the proposed fall, against 6 ft. assumed in the design and, by modifying the design it was shown to be possible to reduce velocities downstream to sub-critical, eliminating the necessity for lining the downstream channel.

Although subsequent model experiments with an unlined channel confirmed these predictions, it was impossible to reproduce similarity of silt conditions or scour of banks; so the results depended largely on the conditions imposed, i.e. on the judgment of the experimenter.'

(3) 'We were asked to make proposals to protect a Railway Bridge, the left abutment of which was being heavily attacked.

The plan did not seem to indicate any cause for such scour, so enquiries were made as to whether any cut-off had occurred in the river. This proved to be the case.

It appears that this cut-off can be closed, an alternative solution which will be much cheaper and more satisfactory than fighting conditions resulting from the river having shortened its course by one mile.'

(4) 'Up to 1923, the Jumna River was flowing along the right bank past the Pumping Station. Subsequently, the river began to move across to the left bank opposite the Pumping Station, necessitating the excavation

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[1] Annual Report of C.I. and H.R. Station, 1939-40.

and continuous dredging of a channel from the left bank to the Pumping Station.

The original remedy we proposed[1] was to remove the upper and lower of the 3 spurs built on the left bank and to build a short spur just below the Pumping Station on the right bank, to draw the river across to that bank.

The efficacy of the design was shown in our model with the equivalent of 100,000 cusecs flowing in the river, which brought the river across in one flood season; but the resulting channel was relatively considerably wider than the Jumna cold weather channel. On subsequent inspection it was considered that as a result of stone crate pitching done along the river face opposite, and downstream of, the Pumping Station, combined with dredging, the river was likely to change across without removing the upper of the three groynes; so developments were awaited. The following year the river moved across to the Pumping Station, as predicted, though the flood discharge was only 31,000 cusecs, or less than 1/3rd that with which the change occurred in the model—i.e. with a discharge which was so low that very little scour could occur with the equivalent discharge in the model.'

(5) 'It has been found impossible to reproduce the changes which occur from year to year in our Ganges model, despite it being a very large model over 500 ft. long. In general, scour has occurred too quickly and silting much too slowly; and consequently the Damukdia channel has reopened too quickly.

If the period of the experiments were reduced it would give the rate of scour of Damukdia channel more correctly but would make other parts of the model still more wrong. Certain it is that the rate of opening of the Damukdia channel was predicted more accurately from experience and judgment than can be indicated by a model.'

At Poona, we have been doing various scale experiments, for several years, with mobile models—to evaluate divergences resulting from various disturbing factors—in order to see how these effects can best be minimized by modifying slope scales, discharge scales, silt charge, and vertical exaggeration away from natural conditions.

These investigations have given us a clear understanding of why certain modifications which we have been carrying out have been successful; but they have not, and cannot, entirely eliminate the inherent divergences nor resolve the numerous complex factors. Natural mobile models do not, in fact, give similarity; but only results which are capable of being translated approximately from river to model and back to terms of river conditions: and results necessarily diverge more and more as the period of the experiment increases.

Frequently it is stated that river results have been verified in a model and have been found to be closely correct. We all, however, seem to relay the model every year according to the latest survey instead of carrying on year after year! The reason given for this is that the flood differed from what was assumed; but the real reason is that only qualitative similarity has been achieved.

[1] C.I. and H.R. Station Annual Reports for 1937-38, pp. 65 to 68; 1938-39, pp. 14 to 16; 1939-40.

Also, as our object is to predict what will happen hereafter—not as a rule for a year or two, but for several years ahead—if the divergences in a single year render it advisable to relay; this, in itself, is an admission of the limitation.

Our experience of verification is that there is rarely enough river data available to make verification satisfactory, except as a rough qualitative check, and even if there were, it would, at best, be a very slow and tedious process; because every appreciable change in one factor affects all the others.

Conclusion

I cannot do better than repeat what I wrote in my Symposium Paper of 1938 for the National Institute of Sciences of India, on 'The use of models for elucidating flow problems':

> 'The general conclusion is that in competent hands, a very wide range of experiments with large models gives results of high qualitative accuracy and may also give quantitative accuracy; but, in the case of river models, the data available is generally meagre, and though the gaps in data can be filled to a large extent by an officer with wide field experience, so that a model can be made to reproduce what has previously occurred in the prototype under known conditions of discharge and silt charge, the problems which generally have to be tackled are of immediate urgency, the discharge data being inadequate and the silt charge data nil, and we are asked "what will happen if nothing is done?" or "what should be done to prevent further damage?".
>
> 'Satisfactory answers depend to a marked extent on an intimate knowledge of the engineering side of the problems under consideration combined with a flair for diagnosis.'

Mobile river models are in fact a valuable aid to engineering skill, which, however, they can never replace.

Although this Address expresses my own viewpoint, yet much of it is based on work done by the Station staff at Poona and I am especially indebted in this respect to Mr. A. R. Thomas, Deputy Director, and Rao Sahib D. V. Joglekar.

Proceedings of the Twenty-eighth Indian Science Congress

PART III—ABSTRACTS

CONTENTS

SECTION OF MATHEMATICS AND STATISTICS

President :—M. RAZIUDDIN SIDDIQI, PH.D.

1. On partitions.

K. SAMBASIVA RAO, Waltair.

Let $a_1, a_2, \ldots a_r$ be a set of positive integers. Sylvester (J. J. Sylvester: *Quart. Jour. Math.*, **1**, 1885, pp. 81–84. Also Dickson's History, vol. 2 (1920), p. 119), Cayley (Cayley: *Phil. Trans. Roy. Soc.*, London, **146**, 1806, pp. 121–140. Also Dickson's History, vol. 2, p. 119) and others investigated the number of partitions of n into parts $a_1, a_2, \ldots a_r$. If $P(a_1, \ldots a_r)n$ denotes that number then their results are roughly equivalent to

$$P(a_1, \ldots a_r)n \sim \frac{n^{r-1}}{(r-1)!\, a_1 a_2 \ldots a_r}.$$

This can also be proved by the elementary theory of partial fractions.

Evelyn and Linfoot (Evelyn and Linfoot: 'On a problem in the additive theory of numbers'—*Math. Zt.*, **30**, 1929, pp. 443–448) obtained an asymptotic formula for the number of partitions of n into lth power-free numbers.

In this paper, generalizing the problems of Sylvester and Cayley and Evelyn and Linfoot, I consider the number of solutions in primes, $p_1, p_2, \ldots p_r$, of

$$\pm a_1 p_1 \pm a_2 p_2 \pm \cdots \pm a_r p_r = n \quad \text{where } a_i p_i \leqslant n.$$

The same method can be applied to find an asymptotic formula for the number of solutions of

$$\pm P_1(p_1) \pm P_2(p_2) \pm \cdots \pm P_s(p_s) = n \quad \text{where } |\, P_i(p_i) \,| \leqslant n,$$

where $P_i(x)$ denotes an integral valued polynomial.

2. On a problem of arrangements.

V. NARASIMHA MURTI, Waltair.

The problem is: '$2n+1$ persons are invited to a dinner on n different days. Is it possible to arrange them on a circular table in such a way that no person has the same neighbour on different days?'.

I have given elsewhere (*Jour. Ind. Math. Soc.* Vol. IV, No. 1, pp. 39–43, 1939) the proof for the existence of a solution of the above problem P_n. The present paper deals with a result regarding the number of solutions of P_n.

Starting from any solution of P_n, we get new solutions: (*a*) by interchanging the figures $1, 2, \ldots .\, 2n+1$, (*b*) by cyclic or anticyclic permutation inside the arrangements, and (*c*) by interchanging the n dinner parties. We shall consider all the solutions obtained by each of these alternations as belonging to an *isomorphic group*, and only such solutions of P_n should be considered to be *different* as correspond to non-isomorphic groups. I shall show, in this paper, that there are at least

three *different solutions* of P_n when $2n+1$ is a prime number and that there are at least two *different solutions* of P_n when $2n+1$ is a composite number. In fact, I prove that the two solutions mentioned in my paper (*ibid.*, pp. 42-43) are two different solutions of P_n, in the sense of the definition of the word 'different solutions' given here, and which is also suggested in his paper (*Jour. Ind. Math. Soc.*, Vol. IV, No. 2, pp. 45-46)—'Remarks on Mr. V. Narasimha Murti's paper—On a problem of arrangements (I)' by Prof. F. W. Levi.

3. The generalized problem of the play of thirteen.

S. M. KERAWALA, Aligarh.

Three players are given three well-mixed packs, each consisting of the same n different cards. They expose together singly cards out of their respective packs. If v_n is the probability that no two of any set of three cards exposed together are the same, reasons are given here for the conjecture that $v_n \sim \frac{1}{e^3}$.

4. On some algebraic relations.

S. C. CHAKRABARTI, Jadabpur.

$$(1) \quad \sum_{x=0}^{n} a^{n(n-x)} \, {}^nS_{n-x} \, {}^nS_x = {}^{2n}S_n,$$

where ${}^nS_x$ denotes the sum of the products of n factors $1, a, a^2, a^3, \ldots a^{n-1}$ taken x at a time.

$$(2) \quad \sum_{x=0}^{k} \frac{{}^nS_{2x}}{a^{2x+1}-1} a^{2x} = \frac{1}{a^{n+1}-1} \cdot \prod_{r=1}^{n} (1+a^r),$$

where $k = \frac{n}{2}$ or $\frac{n-1}{2}$, according as n is even or odd.

$$(3) \quad \sum_{x=0}^{n} \frac{a^x + a^{x-1} - 1}{a^{x-1}} \, {}^nS_x = 2a^{n-1} (a+1) \prod_{r=1}^{n-2} (1+a^r).$$

$$(4) \quad \sum_{x=0}^{n-1} \frac{a^{x+1}-1}{(a-1)a^x} \frac{{}^nS_{1+x}}{{}^nS_x} = \frac{a^{n+1}-(n+1)a+n}{(a-1)^2}.$$

5. On a special recurrent.

S. C. CHAKRABARTI, Jadabpur.

Denote

$$\begin{bmatrix} n \\ c \end{bmatrix} = (a^n - 1)(a^{n-1} - 1)(a^{n-2} - 1) \ldots (a^c - 1),$$

$$\begin{bmatrix} n \\ c \end{bmatrix}_2 = (a^n - 1)(a^{n-2} - 1)(a^{n-4} - 1) \ldots (a^c - 1),$$

${}^nS_r$ = sum of the products of n factors $1, a, a^2, a^3, \ldots a^{n-1}$ taken x at a time and

$$D_4 = \begin{vmatrix} \frac{a^3-1}{a-1}a & \frac{a^3-1}{a-1}a^2 & a^3 & \begin{bmatrix} 3 \\ 1 \end{bmatrix}_2 \\ 1 & \frac{a^2-1}{a-1}a & a^2 & \begin{bmatrix} 1 \\ 1 \end{bmatrix}_2 \\ & 1 & a & -\begin{bmatrix} 1 \\ 1 \end{bmatrix}_2 \\ & & 1 & \lambda-1 \end{vmatrix}_4$$

then $D_n = {}^nS_n\,\lambda-1$.

In D_n, the element in the rth row and kth column is

$$\frac{{}^{n-r}S_{k-r+1}}{{}^{k-r+1}S_{k-r+1}}\,a^{k-r+1}$$

and the rth element in the last column is

$$(-)^{\frac{n-r+1}{2}} \begin{bmatrix} n-r \\ 1 \end{bmatrix}_2,$$

if one of n and r be even and the other odd, and

$$(-)^{\frac{n-r+2}{2}} \begin{bmatrix} n-r-1 \\ 1 \end{bmatrix}_2,$$

if n and r both are even or both odd.

6. A rapid method for calculating the least squares solution of a polynomial of degree not exceeding the fifth.

S. M. KERAWALA, Aligarh.

The ordinary method for finding the least squares solution of a polynomial is very laborious. If, however, the values of the independent variable form an arithmetic series, a method can be devised to give the solution very rapidly. The method given in this paper is an improvement on the method of Birge and Shea (Birge, R. T., and Shea, J. D.: *Physical Review*, **24**, p. 206, 1924). The process of calculating the solution has been divided into three distinct parts:

(1) Calculating the solution corresponding to the standard n values $x_r = r - \frac{1}{2}(n+1)$ of the independent variable. Tables have been constructed for values of n up to 30 to facilitate rapid calculation, and a powerful method has been indicated for $n > 30$.

(2) Testing whether the polynomial selected for fitting the observed quantities is suitable.

(3) Calculating the true solution from the standard solution.

The tables given by Birge and Shea (*loc. cit.*) form one-half of the tables here given; and every figure has been carefully tested on a calculating machine.

7. On some formulae in division in topological algebra.

P. N. DAS-GUPTA, Patna.

In Topological Algebra, called Boolean, addition, subtraction and multiplication are discussed (*vide* Topology of Plane Sets, Newman, Cambridge, 1939). The present paper discusses division formulae which are believed to be new.

8. Tauberian theorems with Kronecker conditions.

S. MINAKSHISUNDARAM, Madras.

Given a series Σa_n, we consider the power series

$$f(x) = \Sigma a_n x^n$$

whose radius of convergence is assumed to be $\geqslant 1$.

Write

$$\overline{\lim_{n\to\infty}} \frac{\sum\limits_{\nu=1}^{n} \nu^{\alpha} a_{\nu}}{n^{\alpha}} = \delta(\alpha), \quad \alpha > 0$$

and

$$s_n = a_0 + a_1 + \cdot\cdot + a_n$$

$$\sigma_n = \frac{s_0 + s_1 + \cdot\cdot + s_n}{n+1}.$$

The following Tauberian Theorems are proved :—

Theorem 1: *If* $\delta(\alpha) \to 0$ *as* $\alpha \to \infty$ *and if* $f(x) \to s$ *as* $\alpha \to 1-0$ *then* $\sigma_n \to s$

That is to say, if $\delta(\alpha) \to 0$ as $\alpha \to \infty$ and Σa_n is summable A then it is summable (C_1).

Theorem 2: *If* $\alpha\delta(\alpha) \to 0$ *as* $\alpha \to \infty$, *then*

$$\operatorname*{osc.}_{n\to\infty} s_n = \operatorname*{osc.}_{x\to 1} f(x)$$

provided the right side is finite.

9. On the differentiability of the integral.

P. D. SHUKLA, Lucknow.

The necessary and sufficient condition for the existence of

$$\frac{d}{dx}\int_0^x \cos\psi(x)dx,$$

where the monotone function $\psi(x) \to \infty$ as $x \to 0$, was considered by G. Prasad. In this paper we consider

$$\frac{d}{dx}\int_0^x \phi\,[\psi(x)]dx,$$

where $\psi(x)$ is monotone and tends to ∞ as $x \to 0$, and $\phi[\psi(x)]$ has a discontinuity of the second kind at $x = 0$.

Two classes of functions, $\phi_1[\psi(x)]$ and $\phi_2[\psi(x)]$, have been defined. In the case of ϕ_1 it has been shown that the integral is always differentiable at the origin. And in the case of ϕ_2 the necessary and sufficient condition for differentiability at $x = 0$ has been found out.

10. On the gradient of plane harmonic, bi-harmonic and multi-harmonic polynomials.

B. R. SETH, Delhi.

Bernstein, Szegö and others have proved some theorems on the gradient of plane harmonic polynomials. In the present paper we get some general results not only for the gradient of plane harmonic polynomials, but also for plane bi-harmonic and multi-harmonic polynomials. As regards the gradient of solid harmonic polynomials, Szegö has given a very interesting result in a recent paper (*Trans. Amer. Math. Soc.*, 47 (1940), 51–65).

11. On certain integral representations of Whittaker and Weber functions.

S. C. DHAR, Nagpur.

The object of this paper is to obtain certain integral representations of Whittaker and Weber functions. The following expression has been obtained :—

$$W_{k+k',\, m+m'}(z) = \frac{z^{m'+k'}}{2i\Gamma(-2k'-2m')\sin(2k'+2m')\pi}$$

$$\times \int_{\infty}^{(+0)} e^{-\frac{1}{2}s}(-s)^{-2k'-2m'-1}\left(1+\frac{s}{z}\right)^{-\frac{1}{2}-m+k'} W_{k-m',\, m-k'}(z+s)\,ds,$$

where k, k', m and m' are any quantities. A particular form of the above integral can be given here:—

$$W_{\alpha,\, \beta}(z) = \frac{z^{\alpha-\gamma}}{\Gamma\{2(\gamma-\alpha)\}}\int_0^{\infty} e^{-\frac{1}{2}s}s^{2\gamma-2\alpha-1}\left(1+\frac{s}{z}\right)^{-\frac{1}{2}-\delta} W_{\gamma,\, \delta}(z+s)\,ds,$$

where $\alpha-\beta = \gamma-\delta$, which can again be written as

$$W_{\alpha,\, \gamma}(z) = \frac{z^{\alpha-\gamma}}{\Gamma\{2(\gamma-\alpha)\}}\int_0^{\infty} e^{-\frac{1}{2}s}s^{2\gamma-2\alpha-1}\left(1+\frac{s}{z}\right)^{-\frac{1}{2}+\mu} W_{\gamma,\, \mu}(z+s)\,ds,$$

where $\alpha+\gamma = \gamma+\mu$, a form obtained by Erdelayi by fractional differentiation, and also in the same way it is possible to obtain

$$D_{n+m}(z) = \frac{\Gamma(-n)}{\Gamma(-m-n)\Gamma m}e^{-\frac{1}{4}z^2}\int_{\infty}^{(+0)} e^{\frac{1}{4}(z+s)^2}D_n(z+s)(-s)^{m-1}ds.$$

12. A self-reciprocal function.

R. S. VARMA, Lucknow.

In this paper a function which is self-reciprocal in the Hankel Transform of order ν is discovered.

13. A note on the Fourier's single integral formula.

R. N. MOHANTY, Cuttack.

If $f(x)$ is integrable (L) in every finite interval and in an interval including x, $f(t)$ is of bounded variation, or satisfies one of the other conditions for the validity of the Fourier series or integral, then

$$\tfrac{1}{2}\{f(x+0)+f(x-0)\} = \lim_{\lambda\to\infty} \frac{1}{\pi} \int_{\to-\infty}^{\to\infty} f(t)\,\frac{\sin\lambda(x-t)}{x-t}\,dt,$$

provided that one of the following conditions is satisfied:

1(a). A positive number a exists such that

$$\int_a^{\infty} \frac{|f(x)|}{x}\,dx \quad \text{and} \quad \int_{-\infty}^{-a} \frac{|f(x)|}{x}\,dx \text{ are finite.}$$

1(b). $\dfrac{f(x)}{x}$ is of bounded variation in (a, ∞) and $(-\infty, -a)$ for some positive a, and tends to zero at infinity.

1(c). $\dfrac{1}{x}\displaystyle\int_a^x f(t)dt$ is of bounded variation in (a, ∞) and tends to zero at infinity, and a similar condition holds in $(-\infty, -a)$.

Condition 1(a) was given by Hobson and Pringsheim and Condition 1(b) was also given by Pringsheim. Condition 1(c) which includes 1(a) but not 1(b) was given by Prasad and is a particular case of the Theorem II of this paper given below in the case $\alpha = 1$, condition 1(a) being a particular case of Theorem 1 for $\alpha = 0$. Hardy and Cossar gave conditions which include both 1(a) and 1(b).

We define $F_\alpha(t)$ as the Reimann-Liouville integral of order α (not necessarily an integer) with lower limit a of $f(t)$ for some positive a and suppose throughout that $t>a$. Then

$$\begin{cases} F_\alpha(t) = \dfrac{1}{\Gamma(\alpha)} \displaystyle\int_a^t (t-u)^{\alpha-1} f(u)du, & \alpha>0 \\ F_0(t) = f(t) & \end{cases} \qquad \ldots \quad (1)$$

We define the mean value $f_\alpha(t)$ of $f(t)$ by

$$f_\alpha(t) = \Gamma(\alpha+1)t^{-\alpha}F_\alpha(t) \quad (\alpha \geqslant 0) \qquad \ldots \quad (2)$$

We prove the following two theorems in this paper.

Theorem 1. If, for some $\alpha \geqslant 0$

$$\int_a^{\infty} \frac{|f_\alpha(t)|}{t}\,dt < \infty \qquad \ldots \quad (3)$$

and a similar condition holds in $(-\infty, -a)$ and if over and above this in an interval including x, $f(t)$ is of bounded variation, or satisfies, etc. (*vide* para. 1).

Theorem 2. If, for some $\alpha \geqslant 1$, $f_\alpha(t)$ is of bounded variation in (a, ∞) and tends to zero at infinity, and a similar condition holds in $(-\infty, -a)$ and over and above this, etc.

14. Conjugate Fourier series and Liouville development.

S. MINAKSHISUNDARAM, Madras.

Let us consider, the Sturm-Liouville equation

$$\frac{d}{dx}\left(P(x)\frac{dy}{dx}\right)+\lambda y = 0 \qquad \ldots \quad \ldots \quad \ldots \quad (1)$$

for the boundary condition

$$y(0) = y(\pi) = 0 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

where $P(x)>0$ and is twice differentiable. Let $\phi_n(x)$ denote the normal orthogonal eigen functions corresponding to the eigen values $\lambda_n>0$ and monotonic increasing. Then the functions $\psi_n(x) = \frac{\phi_n'(x)}{\sqrt{\lambda n}}$ also form a normal orthogonal system. A series of the form

$$\sum_{n=1}^{\infty} c_n\phi_n(x) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

is called a *Sturm-Liouville series*. It can be derived from a function $f(x)$ by the rule

$$c_n = \int_0^\pi f(x)\phi_n(x)dx\,;$$

we shall call the associated series

$$\sum_1^\infty c_n\psi_n(x) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

the series conjugate to (3).

It is known that, if (3) is a Sturm-Liouville series, it converges or diverges at a point according as the Fourier series of $f(x)$ converges or diverges. In this paper, we prove the following:

Theorem:—*If (3) is the Sturm-Liouville series of a function $f(x)$, then the conjugate series (4) converges or diverges according as the conjugate Fourier series of $f(x)$ converges or diverges.*

This suggests the possibility of developing a theory of series of the type (4) along a line parallel to the theory of conjugate Fourier series.

15. A further local property of the allied series of a Fourier series.

S. P. BHATNAGAR, Bhowali (Nainital).

It is known that the convergence, and *a fortiori* summability $(c_1\alpha)$, $\alpha \geqslant 0$, of a Fourier series or an allied series, depends only upon the properties of the function near the point under consideration, though in the case of an allied series the value of the sum does depend upon the values of the function throughout the whole interval of definition. In the case of summability by Cesaro means of negative order, the property may fail at a given point due to the influence of the function in some neighbourhood away from the point.

Hardy and Littlewood (G. H. Hardy and J. E. Littlewood: *Journal Lond. Math. Soc.*, **6** (1931), 281–286) have shown that, for the class of Fourier series and allied series for which $a_n = O\left(\frac{1}{n}\right)$, $b_n = O\left(\frac{1}{n}\right)$ (here a_n, b_n denote the Fourier coefficients and $A_0 = \frac{1}{2}a_0$, $A_n = a_n \cos nx + b_n \sin nx$ and $B_n = b_n \cos nx - a_n \sin nx$), convergence at a given point, or indeed summability (A), always implies summability $(c_1 - 1 + \delta)$. Thus for this class of functions, summability $(c_1 - 1 + \delta)$ is in fact a local property. In the case of Fourier series Bosanquet and Offord (L. S. Bosanquet and A. C. Offord: *Proc. Lond. Math. Soc.*, (2). **40** (1936), 273–280) have shown that for the class of Fourier series for which $a_n = 0\ (n^{-r})$, $b_n = 0\ (n^{-r})$, $0<r<1$, summability $(c_1 - r)$ is also a local property of the function. I (S. P. Bhatnagar: *Proc. Lond. Math. Soc.*, (2). **44** (1938), 315–322) have given an analogous result for the allied series.

Further in the case of the Fourier series Bosanquet has given necessary and sufficient conditions for the sequence nA_n to be bounded by some Cesāro mean and has deduced results about the summability by Cesāro means of negative order of the class of Fourier series summable (A). (L. S. Bosanquet: *Trans. Amer. Math. Soc.*, **39**(2) (1936), 189–204. In this paper Bosanquet does not discuss the problem that the property $nA_n = O(1)(c)$ for Fourier series is a local one, but mentions that there would be such a problem). In the present paper I consider the same problem for allied series and show that $nB_n = O(1)(c_1 r)$, $0<r<1$, is a local property of the function.

16. On 'quasi-helices' associated with curves.

S. M. Kerawala, Aligarh.

There are two fundamental properties of the circular helix, viz. the constancy of the angle made by the tangent with a fixed direction and the constancy of the ratio of corresponding arc-lengths on the curve and the axis. The first property generalized gives the generalized helix. Curves obtained by generalizing the second property for curvilinear axes are here considered. For want of a better name they are here called 'quasi-helices'. I treat here the 'quasi-helices' associated with a general space curve. As particular cases of curvilinear axes, I consider successively the straight line, the circle, the circular helix and that 'two-eyed' spiral of which the intrinsic equation is $\rho = a \cos bs$.

17. On ten associated points in [4].

B. Ramamurti, Ajmer.

In a recent paper (*Journ. London Math. Soc.* (1938), 198), F. Bath has proved the following theorem: Given ten associated points in [4] which do not lie on a rational quartic curve, the rational quartic through any seven of them has the plane of the remaining three as a trisectant plane; also the three points and the three points of intersection with the quartic lie on a conic. The object of this note is to give a simpler, invariant-theoretic, alternative proof of the above theorem.

18. Some properties of rectilinear congruences.

Ram Behari, Delhi.

In this paper rectilinear congruences which consist of a system of lines parallel to a fixed direction have been considered, and some properties of such congruences have been obtained analytically.

19. The use of generalized Dirichlet's integral in solving distribution problems of statistics.

P. V. KRISHNA IYER, New Delhi.

By using the well-known multiple integral

$$\int\int\cdots\int F\left\{\left(\frac{x_1}{a_1}\right)^{p_1}+\left(\frac{x_2}{a_2}\right)^{p_2}\cdots\left(\frac{x_n}{a_n}\right)^{p_n}\right\}$$

$$\times x_1^{l_1-1}x_2^{l_2-1}\cdots x_n^{l_n-1}dx_1dx_2\cdots dx_n$$

$$=\frac{a_1^{l_1}a_2^{l_2}\cdots a_n^{l_n}}{p_1p_2\cdots p_n}\frac{\left|\overline{\frac{l_1}{p_1}}\right.\left|\overline{\frac{l_2}{p_2}}\right.\cdots\left|\overline{\frac{l_n}{p_n}}\right.}{\left|\overline{\frac{l_1}{p_1}+\frac{l_2}{p_2}\cdots\frac{l_n}{p_n}}\right.}$$

$$\times\int_0^w w^{\frac{l_1}{p_1}+\frac{l_2}{p_2}\cdots\frac{l_n}{p_n}-1}F(w)dw;$$

where $x_1, x_2, \ldots x_n$ extend to all positive values subject to the condition

$$\left(\frac{x_1}{a_1}\right)^{p_1}+\left(\frac{x_2}{a_2}\right)^{p_2}+\cdots\left(\frac{x_n}{a_n}\right)^{p_n}<w,$$

it has been shown that it is possible to get the distribution of the following statistics which have been obtained by other methods:—

(1) the mean and the standard deviations of samples from a normal curve;

(2) the mean of samples from Pearson's Type I and III curves.

20. Statistical moments and divisors of numbers, derived from symmetric functions.

M. ZIAUD-DIN, Aligarh.

In Statistics and Theory of Numbers, symmetric functions are well connected. Symmetric functions are defined for n variates and the statistical moments are connected by $n'\mu_r = s_r$, where s_r denotes the power-sum symmetric function.

Tables for symmetric functions of the variates in terms of moments have been constructed by several authors in various ways, e.g. by O'Toole, Sukhatme and Ziaud-Din, up to weight 9.

The author has used Differential Operators and Characters of the symmetric group in formation of the tables and the table of weight ten is almost ready.

The author has previously published a paper showing the relation of symmetric functions to Bernoulli's numbers.

In this paper determinental symmetric functions are used to obtain certain formulae in partitions and divisors of numbers.

21. The Lorenz curve and its generalization.

A. A. KRISHNASWAMI AYYANGAR, Mysore.

The Lorenz curve arose from an attempt by M. O. Lorenz in 1905 to suggest a graphical representation of the inequalities of wealth in a community. A systematic analytical study of this curve is attempted

here, along with some possibilities of its generalization. It is rather remarkable that all the generalized Lorenz curves have the same general shape with the same end-points and obey the same set of restrictive conditions for the first and second differential coefficients. Incidentally, we get a geometrical interpretation of Liapounoff's inequality of moments. Some interesting by-products of the investigation are:

(1) The mean deviation from the arithmetic mean is less than half the range.

(2) If the distances of the mean of a distribution from the extreme values be a and b, and the mean deviation is the harmonic mean between a and b, then the mean difference is also equal to the mean deviation, the Lorenz curve breaking up into two straight lines.

22. On non-normal fields.

P. C. MAHALANOBIS, Calcutta.

The technique of sample surveys has been developed broadly on the basis of the binomial or the Gauss-Laplacian normal variation. Recent investigations have, however, shown that in a large number of cases the variance function is definitely non-normal. It is therefore necessary to develop a systematic method of classification of non-normal fields. In the present paper this question has been considered with special reference to two-dimensional non-normal fields from the point of view of the theory of probability. The use of such classification in planning sample surveys has been indicated.

23. Levi-Civita's gravitational potential.

(SIR) SHAH SULAIMAN, New Delhi.

Levi-Civita, after reducing everything to ordinary space with reference to a fixed Galilean frame, has obtained the equivalent gravitational potential for the relativistic two-body problem. For one centre, his equivalent central force takes the form

$$-\frac{fm}{r^2}-\frac{6f^2m^2}{c^4r^3},$$

where f is the gravitational constant, m the mass, r the distance, and c the velocity of light.

Levi-Civita has assumed that the whole mass is concentrated at the centre, which of course is not true for heavenly bodies. It is shown here that for a sphere of finite radius the effect of the second term vanishes and Levi-Civita's function reduces to the Newtonian form of the inverse square of the distance. His law, therefore, does not correspond with reality.

24. On the problem of n bodies in the relativity theory.

C. RACINE, Madras.

A method of successive approximations has been developed by Droste and de Sitter to form the linear element of the space-time which represents the solution of the problem of n bodies in Einstein's Relativity Theory. Then the differential equations of the motion of the bodies are determined by writing the equations of the geodesics.

In this paper I expose a completely different method of successive approximations. Their convergence is rigorously proved, whereas the question of convergence of de Sitter's approximations is an unsolved problem, which is most likely an extremely difficult one.

The first two approximations are easily obtainable, under certain conditions. I have treated only the first one, and under very general conditions.

25. Stellar distribution.

H. SUBRAMANI AIYAR *and* G. R. WALKER, Trivandrum.

The problem of stellar distribution is approached from the standpoint of star density per square degree relative to the galactic distribution, based on Van Rhijn's (1929) study in the photographic magnitudes 6 to 18. Of these, the five pmg. 6, 9, 12, 15, and 18 here considered are tabulated at 30° intervals in galatitude and galongitude. The cube roots of these are next tabulated to derive the boundaries of their containing spheroids among approximately uniform distribution and the increases for each three pmg. intervals are compared. These spheroids are plotted—though for each 10° interval (Van Rhijn) instead of the 30° intervals tabled—both in the galactic plane and in profile for the important quadrantal planes, radial to and from the galactic centre and that crosswise—i.e. along the path of rotation. Comparison of the outlines brings out the trailing effect of the latter and also (in lesser degree) the preponderance towards the centre.

Having derived the relative scales, the absolute scale in distance is considered. The mean distance by magnitude is developed into the empirical rule $R = 10\ (1{\cdot}46)^{m}$ radials (or parsecs), for the galactic equator. The distances towards the galactic poles are 58% of the equatorial, where uniform distribution predicates a 5 : 1 oblateness for the star spheroids. An approximately uniform distribution of 0·4 solar mass per cubic radial is adopted; correlating this density in a 5 : 1 oblate spheroid with the superficial density over the sphere, we derive 110 radials per unit superficial density per square degree along the galactic plane and 64 radials towards its poles. These values enter the respective directions in the profile diagrams. The effect of galactic absorption is then considered adopting Stebbins' value of $0^{m}{\cdot}36$ per 1,000 radials, and the corrected distances are plotted as well as tabulated. The direction and distance of the centroid for the true galactic plane are found, and their relative increases compared for each 3 pmg. interval. Lastly, the distances and their increase ratios for each magnitude interval as derived from tabulated mean distances are compared with the like derived from the star densities, as an index of the accuracy of the assumptions made.

26. Photographic work on cephied variables.

P. SAMUELS LALL, Lahore.

Nature of the work on cephied variables undertaken in connection with the International Co-operative Scheme for the study of this class of stars, under the direction of Dr. Harlow Shapley, Director, Harvard College Observatory, Cambridge (Mas., U.S.A.). A description of the photographic camera and telescope used in connection with the work at the Panjab University Observatory, Lahore. The areas under observation, a problem in long exposures. Over 1,200 plates taken and developed. The measurement of the plates and final results.

27. A problem in 'Factorisatio Numerorum'.

D. N. SEN, Patna.

Einar Hille in Acta Arithmetica, Vol. 2, No. 1 (1936), considers the function $f(n)$ which gives the number of representations of the natural number n as a product of factors greater than one. In this paper the

properties of $f(n)$ are dealt with in greater detail. It is shown that

$$f(p_{i_1}^{\alpha_1}\, p_{i_2}^{\alpha_2} \ldots p_{i_\nu}^{\alpha_\nu}) = \text{coefficient of } x_1^{\alpha_1}\, x_2^{\alpha_2} \ldots x_\nu^{\alpha_\nu}$$

in

$$\frac{(1-x_1)(1-x_2)\ldots(1-x_\nu)}{2(1-x_1)(1-x_2)\ldots(1-x_\nu)-1}.$$

In particular it is shown that

$$f(p_{i_1}^{\alpha_1}\, p_{i_2}^{\alpha_2}) = \frac{2^{\alpha_1+\alpha_2-1}}{\underline{|\alpha_1}\ \underline{|\alpha_2}} \cdot F(-\alpha_1, -\alpha_2, -\overline{\alpha_1+\alpha_2}, \tfrac{1}{2}),$$

in terms of the hypergeometric series.

A general form for $f(p_{i_1}, p_{i_2} \ldots p_{i_\nu})$ is also obtained.

28. On an upper bound to the radius of stellar configurations.

N. R. Sen, Calcutta.

In a previous communication, a formula was deduced for an upper bound of the radius of a stellar configuration (defined suitably), in terms of the value of the ratio of radiation to gas pressure at the centre. The formula has been sharpened by considering the configuration to be made up of shells of matter in which the polytropic index varies. Further, the upper bound for the radius has been obtained in terms of the stellar masses. Calculations show that for stars of small and moderate masses at least, the results are quite satisfactory.

29. On the energy of a contracting cluster of particles.

B. C. Mukerji, Calcutta.

In a recent paper in Annals of Mathematics Einstein has investigated the question of the existence of singularities in an actual gravitational field produced by a continuous distribution of matter. The gravitational field of a cluster of particles moving in circles has been found. By postulating a density of particles varying inversely as the square of the distance from the centre, Einstein arrives at the paradoxical result, that the energy of a cluster of particles in infinite diffusion first slightly decreases to a minimum and then increases again to infinite value, the diameter of the cluster also increasing at the later stage.

If instead of taking a density varying inversely as the square of the distance from the centre, we imagine the cluster to have uniform density, it appears that the above paradoxical result can be avoided. We then have the energy of the cluster in infinite diffusion decreasing for contraction by about a maximum of 5 p.c. and then again increasing by a small amount for further contraction almost to the limiting volume, the existence of which has been established by Einstein.

This result is likely to have application in the theory of star-clusters or in the formation of nova.

30. Errors of Bernstein's methods of estimating blood-group gene frequencies.

P. V. Sukhatme, New Delhi.

Bernstein has given two methods for estimating *A*, *B*, *O* gene probabilities. Efficiencies of these two methods, known as the old method and the improved method, have been worked out by the author. It is shown that the use of old method which is so widely employed in literature

in place of the maximum likelihood method is equivalent to discarding about 10 per cent of the observations in the estimation of the O gene probability. It is also shown that the loss of information resulting from the use of Bernstein's improved estimates in place of the maximum likelihood estimates is of negligible magnitude, thus verifying Steven's conclusion that Bernstein's improved estimates, although not the best estimates, form ally satisfy maximum likelihood equation.

31. On the k-analogue of a result in the theory of the Riemann zeta-function.

S. Chowla, Lahore.

It is known that there exists an absolute positive constant C_1 such that the relation

$$|\zeta(1+ti)| < \frac{}{\log\log t}$$

is true for infinitely many t $(t \to \infty)$.

The k-analogue of this result is the *theorem*. There exist infinitely many k such that

$$0 < L_k(1) = \sum_{1}^{\infty} \frac{\chi(n)}{n} < \frac{C_2}{\log\log k}$$

where $\chi(n)$ is a real *primitive* character (mod k) and C_2 is a certain absolute positive constant.

This theorem was proved by Littlewood in 1928 on the basis of the unproved 'extended Riemann hypothesis'.

In this paper the theorem is proved without any hypothesis.

32. On the artificially bounded harmonic oscillator.

F. C. Auluck, Lahore.

In a recent paper, because of its astrophysical interest, Sommerfeld and Welker have discussed the Kepler problem subject to an artificial boundary condition which physically corresponds to the hydrogen atom being enclosed in a sphere whose walls are impermeable to the electrons. The ψ-function, therefore, has to vanish on the sphere. The present paper deals with the corresponding problem for the harmonic oscillator. In the usual discussion the ψ-function for the oscillator vanishes at infinity but in our case the ψ-function has to vanish at a finite distance which corresponds to the radius of the sphere enclosing the oscillator. The ψ-function, in this case, is not given by the Hermitian polynomial, but is given by the Weber's parabolic cylinder function, the index varying continuously with the radius of the sphere. The problem has physical and astrophysical applications which are indicated in the paper.

SECTION OF PHYSICS

President:—P. N. GHOSH, M.A., PH.D., SC.D. (Hons.), F.INST.P. (Lond.), F.N.I.

Astrophysics

1. Mass–radius relation for white dwarf star.

D. S. KOTHARI, Delhi.

The usual theory of the white dwarf star gives on the assumption of *hydrogen-scarcity* a value for the radius that is about 2·5 times smaller than the observed value, but is reconciled with observations by assuming an abundance of hydrogen. However, the hypothesis of *hydrogen-abundance* is now untenable in the light of recent advance in Nuclear Physics.

In the present paper the mass–radius relation for a white dwarf (assuming hydrogen scarcity) is deduced by applying Schrodinger's equation for an oscillator to the motion of an electron under the gravitational and electro-static forces inside the white dwarf. The theoretical relation is in good accord with observations.

Acoustics

2. Ultrasonic velocity in solutions.

L. SIBAIYA *and* R. L. NARASIMHAIYA, Mysore.

The variation in the ultrasonic velocity and hence in the adiabatic compressibility with concentration in solutions of naphthalene in organic liquids has been investigated. A convenient method of measuring the ultrasonic velocity (v) in liquids and solutions has been developed and it has already been described (*Ind. Jour. Phys.*, 1940). Using a mercury arc lamp the shift of the diffraction maxima in each solution and the pure liquid has been measured for λλ 5790, 5770, 5461, 4358 and 4047 Å for the same ultrasonic frequency. For the piezo-quartz holder ivory was found to be better insulating material than fibre or ebonite, both of which were subject to serious break-down in insulation after having been in contact with organic solutions for some time. A determination of the density of the solutions and of the pure liquid (ρ) enables a calculation of the variation in compressibility (β) from the relation:

$$-\frac{d\beta}{\beta} = 2\frac{dv}{v} + \frac{d\rho}{\rho}.$$

Solutions of naphthalene in toluene and benzene indicate that the decrease in compressibility is linearly related to molar concentration in dilute solutions. These results as well as the observation that near saturation there is a large decrease in compressibility are explained on the basis of a decrease in the intermolecular free space in a pure liquid as the solute goes into solution.

3. The variation in sound-absorption for a cloth partition with its distance from a reflecting surface.

HAJI GHULAM MOHAMAD, Hyderabad (Deccan).

The present paper is devoted to a study of the variation of sound-absorption coefficient for a thin cloth partition (unpainted) which could be placed at various distances from a perfect reflector. The stationary-wave method was used in making absorption measurements.

The main excuse for carrying out this work is to discover a method of sound-control which would be cheap and at the same time as effective as many of the costlier methods extant, so that a large number of Municipal Schools and Colleges and other similar buildings in India which cannot afford to install costly materials to correct the acoustic properties may utilize it with advantage, though slightly at the expense of architectural aesthetics.

It is found that if the thin cloth partition be placed at a quarter wave-length distance from a reflector its sound absorption coefficient α becomes as high as 0·35 which is even higher than that for Treetex ($\alpha = 0{\cdot}31$ at 512 cycles) or Acousti-Celotex ($\alpha = 0{\cdot}25$), the costly commercial substances so largely used all over the world to control sound. These results are remarkable in that they point out to the possibility of opening up a new field for manufacturing sound-absorbing substances at very low costs with an added ease and low cost of installation.

Electrostatics

4. Electrical energy of two cylindrical charged particles.

G. P. DUBE, Agra.

Two parallel cylindrical particles, of circular cross-section a with a distance sa apart, and surface charge density σ are immersed in water containing a known electrolyte. The potential ψ is assumed to be given by Debye-Hückel equation $\Delta^2\psi = \kappa^2\psi$ where κ is the characteristic quantity in Debye-Hückel theory. A suitable solution for a single particle is $\psi = \dfrac{4\pi\sigma K_0(\kappa r)}{K_1(\tau)}$ where $K\nu(z)$ is the modified Bessel function of the second kind, D the dielectric constant and $\tau = \kappa a$. The Zeta-potential then becomes $\xi = \dfrac{4\pi\sigma K_0(\tau)}{K_1(\tau)}$, and the electrical energy is now given by

$$F = \frac{D\xi^2}{8} \cdot \frac{1}{K^2{}_0(\tau)} \left[K_0(s\tau)\phi(\tau) - s\tau K_1'(s\tau)\right]$$

where $$\phi(\tau) = 2\tau^2\left\{I_0(\tau)K_2(\tau) + I_1(\tau)K_1(\tau)\right\}$$

$I\nu(z)$ being the Bessel function. This seems to exhibit a minimum for a certain value of s and hence may be of importance in explaining the thixotropic properties of rod-shaped particles.

General Physics and Heat

5. Effusion phenomena in a degenerate Bose-Einstein gas.

D. V. GOGATE, Baroda.

Expressions are derived, in this paper, for the effusion of number, mass and energy in the case of a degenerate Bose-Einstein gas taking into account the effect of relativity Mechanics. It is found that whereas in the case of a non-degenerate gas the effusion of number, mass and energy depends, for a given value of temperature T, on the concentration

n, it becomes independent of n in the case of a degenerate gas. The effusion of one degenerate gas into another is also discussed and it is shown that these formulae for effusion in the case of Bose-Einstein degeneracy do not involve n_1 and n_2 but only T_1 and T_2 and that the phenomenon of thermal transpiration does not occur in this case for, the equality of the rates of effusion from gas 1 to gas 2 and from gas 2 to gas 1 automatically implies the equality of T_1 and T_2.

6. Effect of electric field on the viscosity of liquids.

S. P. PRASAD *and* B. N. SINGH, Patna.

A new experimental arrangement to study the effect of electric field on the viscosity of liquids is described. The electric field acts in a direction at right angles to that of flow of liquids and it has been so devised that no continuous electric conduction takes place in the liquid. Thus it is possible to eliminate entirely any spurious changes in the viscosity due to the movement of ionic impurities under the action of the applied electric field. With the new arrangement the rate of flow of a number of polar liquids, e.g. nitro-benzene, ether, ethyl acetate, and xylene have been observed with and without the electric field. The maximum field strength varied from liquid to liquid, ranging from 15 to 50 kv/cm. No appreciable change occurs in the viscosity of any of the liquids examined on the application of the electric field.

7. Thermal transpiration of a dissociating gas.

B. N. SRIVASTAVA, Allahabad.

In this paper the thermal transpiration of a dissociating gas has been investigated theoretically for two chambers maintained at different temperatures and communicating with each other through a narrow opening. It has been shown that the condition of thermodynamical equilibrium and the usual transpiration relation for each constituent cannot both be satisfied simultaneously. In §2 the problem has been treated rigorously from the view-point of a steady state. Expressions have been worked out showing how the law of mass action suffers modification in this case. Expressions have also been deduced for the atomic and molecular concentrations in the two chambers and the modified transpiration relation is stated. In §3 an approximate solution of the problem has been given which is based on the assumption of thermodynamical equilibrium in each chamber. Expressions have been deduced for the absolute magnitude as well as the ratio of the atomic or molecular concentrations in the two chambers in the general case and in some limiting cases. Finally the relative merits and demerits of both the treatments have been clearly set forth.

8. Thermal ionization of strontium.

B. N. SRIVASTAVA, Allahabad.

In this paper the thermal ionization of strontium vapour has been experimentally investigated by an apparatus already described by the author in his earlier work on barium (*Proc. Roy. Soc.* A, **175**, 26, 1940). Experiments have been carried out at various temperatures and pressures of strontium vapour and the equilibrium concentrations of ionized strontium and electrons inside the furnace have been obtained by allowing them to effuse out through a narrow opening. This gives the equilibrium constant. The energy of ionization has been calculated by utilizing the well-known ionization formula. The results obtained agree, within the limits of experimental error, with the theory of thermal ionization and the known spectroscopic value of the ionization potential of strontium.

9. Temperature-pressure variations of a gas subjected to low frequency corona discharges.

HARIRAO J. ARNIKAR, Benares.

A rise in the pressure of a gas subjected to a corona electric discharge is long since known, but conflicting views are entertained as to the origin of the pressure-rise, one view, chiefly due to Kunz and his collaborators, (Kunz, *Phys. Rev.* 1914, **4**, 31, also *ibid.*, 1916, **8**, 285 also *ibid.*, 1922, **19**(2), 165) is that the pressure rise is due to an increase in the number of gas particles due to ionization, while the other view of Tyndall (Tyndall and Searle, *Phil. Mag.* 1918, **35**, 261) is that the pressure effect is purely of thermal origin. Thus far no attempt seems to have been made to measure directly the temperature changes of the gas due to the discharge. It is the object of the present paper to measure the temperature pressure variations in different gases subjected to the discharge and see how far these variations are compatible with the gas laws. An efficient and necessarily elaborate system of cooling the electrodes has been developed and the corona effects have been studied in hydrogen, nitrogen, air and oxygen for different initial pressures and for different voltages and A.C. frequencies. Effects of including a spark-gap, a condenser and of silvering the electrode walls have also been studied. Data show a perfectly synchronous variation in the pressure and temperature of the gas. The complete agreement between the pressure observed and that calculated for the observed temperature-rise, the system having attained a steady state, the negligibly small degree of ionization as may be computed from the feeble current observed, conclusively show the pressure effect to be entirely of thermal origin.

10. Thermal conductivity of liquids.

M. RAMA RAO, Bangalore.

Considering a liquid near its melting point as an assemblage of linear harmonic oscillators each vibrating with a frequency ν about a slowly displaced equilibrium position and assuming that communication of thermal energy takes place at each extreme libration, it is shown that the thermal conductivity at the melting point is given by $K = 4\kappa\frac{\nu}{\sigma}$ where ν is the Lindemann frequency, σ is the mean molecular distance and κ the Boltzmann constant. Substituting for ν, $2{\cdot}8 \times 10^{12}\sqrt{\frac{\theta_s}{M V_s^{2/3}}}$ where θ_s is the melting point, M the molecular weight, V_s the molecular volume, it is shown that calculated values of thermal conductivity are in agreement with observed values.

11. Joule-Thomson and Joule effects in Fermi-Dirac and Bose-Einstein gas.

B. N. SINGH, Delhi.

Various properties of matter obeying Fermi-Dirac and Bose-Einstein Statistics have been investigated recently. The Joule-Thomson effect for a non-relativistic Fermi-Dirac degenerate gas has been considered by Kothari. Srivastava has considered the non-relativistic non-degenerate cases of Fermi-Dirac statistics, and Gogate has extended the discussion to relativistic, degenerate and non-degenerate cases of Fermi-Dirac statistics. In this paper the Joule-Thomson effect for a degenerate Bose-Einstein gas has been calculated and the Joule

effect has been studied for matter obeying Fermi-Dirac and Bose-Einstein statistics, and the following conclusions have been reached.

1. A Fermi-Dirac gas is always heated in undergoing a Joule-Thomson or Joule expansion and the rise in temperature is greater the greater the degree of degeneracy of the gas. However, the degree of degeneracy is diminished in the process.

2. A Bose-Einstein gas is always cooled when undergoing either process and the fall in temperature is greater the greater the degree of degeneracy, and as before the degree of degeneracy is diminished in the process.

3. There is a sudden increase in the amount of cooling produced in the relativistic case of the Bose-Einstein gas at the point of transition from non-degeneracy to degeneracy. There is no such discontinuity in the non-relativistic case.

12. The development of ellipticity in the orbit of Foucault's pendulum of short length.

B. DASANNACHARYA, Benares.

The elliptic orbit of Foucault's pendulum caused by the Coriolis force is very small while in actual experiments the ratio of the minor to the major axis of the orbit does become very large, very seriously affecting the results for the Foucault rotation $\theta = wts$ in λ in a time t, where λ is the latitude of the place of observation and w the angular velocity of earth's rotation about its axis. It is exceedingly difficult to get rid of these effects. Careful experiments have shown that due to the rigidity of the suspension-string and asymmetry in the clutching of the string for support at top, the simple pendulum becomes double periodic showing Lissajous rotation which is naturally superimposed on the Coriolis effect. The difference in the two periods is exceedingly small and can be connected with the Youngs Modulus of the suspension wire. The effect will be demonstrated by experiments with Kaleidophone made of wires of different thicknesses and lengths.

Magnetism

13. Magnetic susceptibility of cadmium amalgams.

H. S. VENKATARAMIAH, Bangalore.

The magnetic susceptibility of dilute cadmium amalgams prepared by electrolysis of cadmium chloride having a mercury cathode and also by direct solution of cadmium metal in mercury has been measured. The results obtained are compared with the mass susceptibility of the amalgam calculated according to the mixture law assuming the specific susceptibility of cadmium to be $-0{\cdot}18 \times 10^{-6}$ C.G.S. units. The difference between the observed and the calculated values is traced to the increase in the net paramagnetism of the conduction electrons, whose effective number becomes larger in the amalgam than in pure mercury.

Oscillations and Waves

14. Investigation on the atmospherics at Dacca on wave-lengths from 15 metres to 150 metres.

S. R. KHASTGIR *and* MD. INNAS ALI, Dacca.

This investigation on the atmospherics carried out at Dacca during the monsoon time on wave-lengths from 15 metres to 150 metres (2 Mc. to 20 Mc. frequency) is only a part of a year's programme of work. The

peak-method of measurements was employed and experiments were carried out in accordance with the programme along the following lines:

I. Determinations of the numbers of atmospherics from different directions on different wave-lengths at different times of the day, with special reference to the sunrise and the sunset times.

Usually one and occasionally two maxima, a few minutes before the local sunrise time were observed. The number of atmospherics was found to be minimum from about 12 to about 2 in the afternoon. Just about sunset time a minimum was followed by one maximum and occasionally two maxima a little after the local sunset time.

II. Measurements of the field-strengths of the atmospherics from the East-West direction (and occasionally from the North-South) on different wave-lengths at different times of the day with special reference to the sunrise and the sunset times.

Usually one and sometimes two maxima were observed a few minutes before the local sunrise time. One maximum and occasionally another were observed about and a little after the local sunset time respectively. Soon after the maximum immediately before the sunrise, the field-strength decreased rapidly and continued diminishing till sometime after the sunrise. There was a subsequent rise, indicating in some cases a small maximum an hour or two after sunrise. The atmospheric field-strength was usually large late in the afternoon.

A general explanation has been given in the paper.

III. Day-to-day determinations of the directions of arrival of maximum atmospheric disturbance at three specified hours of the day on two wave-lengths 30 m. and 60 m.

IV. Hour-to-hour determinations of the directions of arrival of maximum atmospheric disturbance for some days.

V. The frequency distribution of atmospherics from the East-West was studied in two different ranges of wave-lengths, viz.: 60 m. to 150 m. and 15 m. to 30 m. as follows.

(*a*) Measurements of field-strengths of distant atmospherics during day and night.

It was found that the day-time atmospheric field-strength was *inversely proportional to the square of the frequency.* During night-hours the atmospheric strength was found to *decrease exponentially with the increase of frequency.*

(*b*) *Measurements of atmospherics of near origin during local thunder-storms.* It was found that in most cases the atmospheric field-strength was *inversely proportional to the frequency.*

(*c*) *Measurements of field-strengths of the 'rain-statics.'* The frequency distribution of these atmospherics was similar to that for atmospherics from centres of local thunderstorms.

VI. The average values of the daily maximum peak-strength of the atmospherics on 30 m. and 60 m. during morning, afternoon and night hours for the months of May and June were determined and an estimate of the signal strength values for good reception about this time at Dacca on these wave-lengths is given.

15. Some studies in the atmospherics at Dacca on medium radio-frequency.

S. R. KHASTGIR *and* R. G. BASAK, Dacca.

In this investigation on the atmospherics received at Dacca on medium radio-frequencies, a detailed study of the field-strengths of the distant atmospherics during local sunrise and sunset times was made. Two types of results were obtained in the early morning experiments:

(1) The field-strength of the atmospherics diminished rapidly long before the local sunrise time and continued diminishing till sometime after the sunrise time. There was a subsequent rise (sometimes gradual

and sometimes rapid) indicating occasionally a maximum, an hour or two after sunrise.

(2) In some sets of observations an unmistakable maximum in the field-strength value was observed about 8 to 10 minutes before the local sunrise time. Sometimes another maximum which was less pronounced than the first was also observed about 10 or 15 minutes earlier than the first, and there was the same rapid decrease in the atmospheric field-strength immediately before the sunrise and even after it for a while.

The evening observations almost always indicated a maximum about the local sunset time.

The measurements of the field-strengths of the atmospherics coming from the East-West and the North-South directions were made following the well-known peak-method of atmospheric noise measurements. The observations for the two directions were alternately taken and the alternate observations revealed exactly similar features.

A general explanation is given of the sunrise and sunset effects.

The directions of arrival of the atmospherics for some days were also determined.

Further experiments on the frequency distribution of the received atmospherics over a limited range of medium radio-frequencies were also made.

16. On electrical disturbances to radio broadcast reception.

N. L. Dutt *and* S. P. Chakravarti, Calcutta.

The paper relates to studies on disturbances from electrical sources (common in Indian city areas), e.g. D.C. fan, pump and tool motors; refrigerators and car ignition systems—to medium and short wave broadcast reception.

Studies have been undertaken under the following heads: (1) measurement of noise voltage output at different wave-lengths in 13–150 metres and 200–545 metres bands at a fixed distance from the source,

(2) measurement of noise voltage output at various distances from the source on different wave-lengths in short and medium wave bands, and

(3) directional radiation characteristics of the source on different wave-lengths.

It has been found that the noise level from fan is highest on the wave bands 55–75 metres and 150–250 metres, although it is sufficiently high on the bands 13–15 metres and 35–45 metres and is quite low on the bands 16–22, 45–55, 80–100 and 350–545 metres. The noise level (S) has been found to vary with distance (D) according to the law $S = Ae^{-\gamma D}$ for both short and medium wave-lengths. The directional curves of the normally suspended ceiling fan for wave-lengths in medium and short wave bands are not circular and indicates that radiation may be greater in certain directions. Discussion on the results is given.

17. On the polar diagrams of ultra-short wave horizontal transmitting aerials.

S. S. Banerjee *and* G. C. Neogi.

Polar diagrams of several types of directional aerials have often been studied by various investigators, but a similar study with horizontal aerials has not yet received adequate attention owing to their comparative recent application in ultra-short wave communications. Mention should, however, be made of the valuable investigation in this direction by Meissner (*Proc. Inst. Rad. Eng.*, Vol. 15, p. 928, 1927) and Niessen (*Ann. der Phys.*, Vol. 33, p. 404, 1938).

In the present paper polar diagrams for various distances have been investigated with ultra-short wave horizontal transmitting aerials of different lengths. In order to draw the polar diagrams the intensities of radiated field-strengths around a horizontal transmitting aerial were determined by a calibrated ultra-short wave receiver of super-regenerative type. For the purpose of radiation a modulated valve oscillator generating waves 4 to 8 metres long was employed in conjunction with a half-wave aerial. The observed values of field-strengths were compared with those calculated mathematically by the formulae developed by the method of 'induced e.m.f.'. The exact directions of the maximum and minimum amount of energy-flow from the transmitting aerial have been determined by theoretical calculations and the results obtained thereby have been verified by experimental observations. It has been noticed that aerials of different lengths radiate the energy along different channels and the polar diagrams for a particular length of the aerial depend on the distance at which the field-strengths are measured.

18. Overall voltage gain of low frequency amplifiers with negative resistance.

S. S. Banerjee *and* A. S. Rao, Benares.

It is a matter of common experience to find the actual overall voltage gain of a low frequency amplifier of more than one stage to be measurably less than the gain theoretically calculated from the associated circuit and tube constants. This discrepancy has often been attributed to the stray as well as fixed capacities and inductances involved in the circuit and also to the behaviour of the tube under the circumstances. The definite conclusions, however, seem to be still lacking.

The present paper is concerned with a detailed study of low frequency amplifiers investigating the cause of loss of amplified voltage during the transfer of energy from one valve to the next following it. Analyzing the circuit of a two-stage low frequency amplifier with resistance-capacity coupling, it has been observed that the primary seat of attenuation of voltage lies in the inter-valve coupling components and out of which the grid resistance only can be varied at will for compensating the loss incurred and also without causing any serious effect on the working condition of the amplifier. The minimum loss of voltage is, however, obtained only by a negative resistance in the grid circuit of the valve and the exact value of this resistance can be calculated from equations derived for the purpose. The condition of minimum loss has been verified experimentally by using negative resistance of a dynatron valve along with a fixed positive resistance in parallel with it in the grid circuit of the valve in the second stage of the amplifier.

19. Rectification in discharge tubes.

V. T. Chiplonkar, Benares.

Using the same method of observation as reported previously (*Proc. Ind. Acad. Sci.*, 10, 381, 1939), a detailed study has been made of the pressure variation of the rectification ratio ρ in discharge tubes, as a function of the relative sizes of the electrodes and the inter-electrode distance l.

The rectification ratio ρ is found to be determined to a very great extent by the pressure in the tube. The variation of the rectification with the relative sizes of the electrodes or σ (which will represent here the ratio of the areas of the two electrodes) is therefore appreciably determined by the pressure at which the measurements are made. This is specially true for low pressures of the order of 1·0 to $2{\cdot}0\times10^{-2}$ cm. for which range, the rectification does not show any simple dependence on σ. For

higher pressure, however, than the above, ρ varies with σ in a direct manner, higher values of σ leading to higher values for ρ.

There is a great difference in the rectification pressure curves obtained in the case of air and hydrogen; on the other hand, the curves reveal an unmistakable similarity in the case of air and nitrogen. The data are, however, insufficient to permit of any generalization. The curves obtained for the high pressure range 0·1 to 1·0 cm. of Hg are very complex and show numerous abrupt maxima and minima.

20. Instability of the atmospheric electric field during the epoch of its evening maximum.

A. VENKAT RAO TELANG, Bangalore.

Several records of the atmospheric electric field show characteristic instability of the field coinciding with the phenomenon of the evening maximum between 19 and 20 hours, standard time. It may show: (i) a sharp needle-shaped peak, (ii) a sudden collapse of the field, (iii) a collapse followed by partial recovery, showing a deep dent in the curve, (iv) a sharp run to negative with equally sudden recovery, reminding us of the effect of a light drizzle, and (v) actual drizzle with its field inversion.

It is shown that at the time of these phenomena, on the average, the temperature is falling, the humidity is rising, the electric conductivity of the air is falling steeply, the wind velocity is low and the probability of precipitation is high. Bearing these and other facts in mind, an explanation of the continued rise of the field to a maximum and the subsequent fall, and the frequent instability of the field during this epoch is offered. The explanation is based on the condensation of moisture on dust nuclei and ions and the sedimentation of these minute droplets, often showing up as evening mists, the phenomenon occasionally reaching the proportions of a very light drizzle.

21. On the velocity of wireless waves.

H. B. MOHANTY, Cuttack.

It is generally assumed that wireless waves travel over the ground with the velocity of light. The electrical properties of the ground may, however, influence the velocity to a slight extent. But certain American experimenters who measured the time of travel of short pulses of wireless waves to a distant station and back found the velocity was variable and was about $\frac{1}{2}$ to $\frac{2}{3}$ the velocity of light. Other experimenters have measured the velocity by different methods, but unfortunately they have measured the phase-velocity of propagation and not the group-velocity. It was with a view to measure the group velocity and to test the conclusion of the American workers that we developed a technique to measure the rate of travel of high frequency pulses between two stations. The results showed that the velocity of propagation was within a few per cent of that of light, disproving thereby the conclusion arrived at by the American workers. Accidentally, an explanation was found for the unexpected result obtained by them and the condition of the ground as regards its moisture content was found to have no appreciable effect on the velocity of propagation.

Spectroscopy

22. A circular periodic chart.

L. SIBAIYA, Mysore.

A new periodic chart, based essentially on the distribution of electrons in the various shells K, L, M, N . . . . and subshells s, p, d, f, is suggested.

The rare earth elements from Ce^{58} to Lu^{71} find a proper place, as the electrons successively enter the 4f subshell. While the elements are arranged in order of increasing atomic weight in the Mendeleeff chart, the new chart brings into prominence the rôle of the atomic number in atom building. The various chemical groups and subgroups, the electron configuration of the ground state of the atom and its corresponding spectroscopic term are all indicated in the chart. Retaining all the advantages of the Mendeleeff chart, this circular periodic chart helps one to follow the process of atom building.

23. Interaction of atomic energy levels. Part IV.

T. S. SUBBARAYA, K. SESHADRI, *and* N. A. NARAYANA RAO, Mysore.

Investigations undertaken with the object of finding the effect of the mixing of two elements on the intensities of their spectral lines, due to mutual interaction of the atomic energy states, have been continued by studying the spectra of tin, mercury and their mixture, produced by a discharge from a 4000 volt, 3 KVA transformer. The following is the list of lines which alter in relative intensity in the mixture:

Tin.

Strengthened:	Weakened.
2840, 2851, 3034, 3175, 3262.	2317, 2335, 2355, 2422, 2429, 2484, 2496, 2547, 2572, 2594, 2661 4525.

Mercury.

Strengthened:	Weakened.
2464, 2536, 2652. 2654, 2655, 2753, 2857, 2894, 2967, 3984, 4078, 4108.	2400, 2639, 3704.

An explanation for these observed changes of intensity on the basis of impacts between metastable and normal mercury and tin atoms is given.

24. The spectrum of mercury in an electrodeless discharge.

T. S. SUBBARAYA *and* R. L. NARASIMHAIYA, Bangalore.

As a preliminary to the study of the hyperfine structure of spark lines an electrodeless discharge in mercury has been studied. Using a continuous wave excitation with 1500 volts on the anodes of the push pull oscillator, only arc lines with high series members were obtained. When H.F. damped waves from the spark discharge of a 20,000 Volt transformer were used, a large number of lines of singly ionized mercury were observed without any classified lines of Hg III. Many of the Hg II lines are still unclassified and a full list of the observed lines is given. The hyperfine structure of λλ 6149, 5889, 5871, 5677 of Hg II has been examined with a glass Lummer plate and a Fabry-Perot etalon. All the lines were found to be single within the resolution available. Further work is in progress.

25. Excitation of light emission from quartz under impact with canal rays of hydrogen and nitrogen.

V. T. CHIPLONKAR, Benares.

This gives a preliminary report of an investigation carried out on the subject. The quartz window is fixed at a distance of about 5·0 cm. from the canal, at an angle of about 45° with the axis of the discharge tube. The spectrograph is kept making an angle of nearly 90° with the discharge tube. Care is taken to eliminate the direct light from the canal ray beam as far as possible. The greenish-white light given out by the quartz, at the point of impact is focussed by means of a cylindrical quartz lens on the slit of the spectrograph.

The spectra obtained show a number of groups of lines, which appear on first examination to be characteristic of oxygen and silicon. More interesting is the change in the intensity distribution of the hydrogen continuum in the case of excitation by canal rays of hydrogen. Microphotometric curves show two distinct maxima in the regions λ 4000Å and λ 3200Å with a shallow minimum in between at about λ 3600Å. In the case of excitation by canal rays of nitrogen, only the groups of lines characteristic of oxygen and silicon, make their appearance without the presence of the continuum. It would appear as if the alteration produced in the intensity-distribution is not characteristic of quartz but of hydrogen itself.

26. Problem of true measure of relative band intensities.

N. R. TAWDE *and* V. S. PATANKAR, Bombay.

Various measures are in use for representing the relative band intensities. Either resolved or unresolved bands are used for this purpose. In the case of resolved bands, integration method can be adopted to measure each structure line separately to obtain gross 'weight' of the band. Alternatively, only a few structure lines having the same quantum numbers in the different bands can be chosen and their intensities compared.

In unresolved bands, integration method involves the determination of the area under the contour of the bands to be compared. Alternative method is to correlate the bands by estimation of 'peak' or 'head' intensities.

In this investigation, the merits and demerits of the different methods have been examined at length and conclusions arrived at regarding the true measure of relative band intensities.

27. Study of the intensity theories in the molecular spectra: second positive system of nitrogen.

N. R. TAWDE *and* V. S. PATANKAR, Bombay.

The theories of emission and excitation probabilities as given by Hutchisson and developed by Langstroth on the basis of wave-mechanics have been examined in the case of second positive system of nitrogen. Theoretical calculations have been made according to Hutchisson's formula to determine the emission probabilities and these used in conjunction with Langstroth's excitation probability gives the 'complete' intensity. Experimental data on the integrated intensities of bands have been obtained by methods of spectral photometry to test the predictions of the theory. Improvement in the agreement resulting from interchange of quantum numbers of bands in the theoretical calculations has been explained and the results in general have been critically examined.

28. Spectral characteristics of the nitrogen molecule in air.

N. R. TAWDE *and* V. S. PATANKAR, Bombay.

Foreign gases or impurities are known to influence the spectra of gases to a large extent. Dry air contains besides nitrogen, an admixture of gases, such as oxygen, argon, carbon-dioxide, hydrogen, neon, helium, krypton and xenon in variable amounts. When excited in discharge tube, air gives the characteristic nitrogen band systems. One may expect that the spectral characters of these may be influenced to a more or less extent by the presence of other air gases mentioned above. The present investigation has been undertaken with a view to study this problem quantitatively. Remarkable effects have been noticed and they have been discussed at length in the paper.

29. Interpretation of the band spectrum of manganese monoxide, MnO.

A. K. SEN-GUPTA *and* B. K. CHAUDHURI, Calcutta.

The band spectrum of manganese monoxide has been previously observed by several investigators under low and moderate dispersions, showing single-headed bands, which in some cases look diffuse. An analysis of the vibrational structure of the spectrum has also been attempted, but it is found that the vibrational coefficients are not of the right order of magnitude which one would expect from an analogy with other homologous diatomic molecules. Furthermore, from considerations of the fact that a diatomic manganese monoxide (MnO) molecule consists of an odd number of extranuclear electrons, one would expect its band system to arise from a transition between electronic states of even multiplicity and to show multiple heads or at least multiple branches or structure lines under favourable conditions. Until this has been ascertained one cannot with certainty assign the emitter of the spectrum as due to MnO or MnO^+.

In the present investigation the spectrum has been photographed under the high dispersion obtainable in the first and second orders of a 21-ft. concave grating, having a dispersion of about 0·6 A.U. per mm. in the second order. The high dispersion spectrograms reveal the following interesting features, viz.:

(i) Most of the strong bands, excepting (0, 0), (0, 1) and (0, 2), show distinctly double heads, the higher wave-length component being more intense of the two.

(ii) The bands (0, 0), (0, 1) and (0, 2) are headless, the diffuse head-like structure under low dispersion being resolved in each case into a large number of pairs of faint but sharp lines.

(iii) Excepting the first members in the sequences, $\Delta v (= v' - v'') = 0$, -1 and -2, others possess definite double-heads.

(iv) The interval between the double heads, where observable, is almost invariable in magnitude.

In the present paper, these features have been interpreted in the light of the recent theory of band spectra and of measurements of the structure lines and their analysis for some of the strongest bands. The band system is found to arise from a transition between two similar and doublet electronic states, the more likely transition being ${}^2\Sigma \rightarrow {}^2\Sigma$. The value of B_v in the lower state changes inappreciably with increasing v''-values while that in the upper state changes appreciably with v'-increasing. A new band-head equation has also been worked out with the improved data now available, and the vibrational constants have the expected values.

30. The band spectra of the monoxide and monochloride of bismuth.

S. K. RAY *and* P. C. MAHANTI, Calcutta.

The present paper deals with the identification and analysis of the band spectra obtained in absorption of bismuth trichloride as well as in the flame of an arc fed with the same salt. Measurements of band heads have been done from plates taken with a Hilger E1 spectrograph with interchangeable quartz and glass optical systems. From a comparison of the emission and the absorption spectra, it has been found that the bands lying above λ 5400 and extending as far as λ 7000 are present only on emission plates. These bands are partially resolved and do not appear on the absorption plates, which however, show two well-developed band systems, one lying in the blue-green region between λ 4300–λ 5700 while the other in the violet region between λ 3600–λ 4000. The latter two systems are due to the monochloride of bismuth, as in favourable cases, isotopic heads due to Cl^{35} and Cl^{37} have been distinguished and measured. The red bands, on the other hand, do not show isotopic heads and are undoubtedly due to the monoxide of bismuth.

It is further noticed that the violet bands of bismuth monochloride are absent on the emission plates, although they have the same lower state as that of the blue-green bands. This suggests that the upper state of these bands is unstable.

31. On the continuous emission spectra of electrical discharges through the vapours of $SnCl_2$, $SnCl_4$ and $SiCl_4$.

R. K. ASUNDI, Benares.

Description and measurements of the continuous emission spectra observed are already given (*Proc. Phys. Soc.*, London, **50**, 581, **1938**). It is likely that these spectra are really emitted by the excited molecules of the vapours. With this assumption, on constructing simplified Franck Condon diagrams to illustrate the energy levels of the various systems of separated atoms and the ground states of the molecules with the help of known spectroscopic and thermochemical data, it is found that a simple relation, similar in all cases, exists between the continuous spectra and the electronic terms of the molecules in question, which possibly is the explanation of the existence of the continuous bands. The work is done in collaboration with Dr. R. Samuel and Dr. S. M. Karim.

32. On some emission bands probably due to SiO_2.

R. K. ASUNDI *and* NAND LAL SINGH, Benares.

A spark discharge between two glass tubes which act as secondary electrodes of a powerful induction coil can be so arranged as to consist of a brilliant yellow point on one electrode and an intense white point on the other, bridged by the usual pink colour of the spark in air. The spectrum of the white spot gives, in the visible region six distinct groups of closely packed bands which are not well resolved by the constant deviation glass prism spectrograph used. Preliminary measurements of wave numbers (uncorrected) of the maxima of intensity in each group obtained from measurements both of the spectrum plate and a microphotometer plate of the spectrum are given in the following table. The measurements are not very accurate and have probably an error of + 25 cm.$^{-1}$.

ν cm.$^{-1}$	$\Delta\nu$
16076	
	1135
17211	
	1028
18239	
	1006
19245	
	947
20192	
	942
21134	

In the ultra-violet the spectrum shows the well-known SiO bands whose frequencies of vibration in the excited and unexcited states are 851·5 cm.$^{-1}$ and 1242 cm.$^{-1}$ respectively (H. Sponer: *Molekül spektren*). The near correspondence of $\Delta\nu$ values observed above and the frequencies of the SiO bands probably indicate that these bands are to be attributed to SiO_2 molecule. Compare similar correspondence between SiCl and $SiCl_2$ bands (*Proc. Phys. Soc.*, London, Vol. 50, 159, 1938).

Further work under higher dispersion and resolution is necessary.

33. Spectrum analysis of mineral contents of fruit parts.

L. SIBAIYA, Mysore.

Using a high frequency spark discharge of the type employed by Walther Gerlach and Werner Gerlach in their study of biological specimens, the mineral contents of certain fruits—like mangoes, plantains, grapes, oranges and apples—have been investigated spectroscopically. It has been shown that the mineral content differs in different parts of the same fruit and the conclusion is drawn that generally the outer covering of a fruit is richer in calcium, magnesium, manganese and silicon.

34. Spectrophotometric measures in the solar spectrum and multiplet intensities.

A. L. NARAYAN, Kodaikanal.

In continuation of the series of observations and measurements previously reported, the intensity profiles of 12 strong Fraunhofer lines of H, Na, Mg and Ca are measured at different points of sun's disc from centre to edge. The photoelectric spectrophotometer employing direct current amplification, recently designed and constructed by the author has been used for the purpose. From the observed total absorptions, the population of atoms in the lower energy level is determined in each case. Attempts have also been made to determine the relative intensities of H_β line in sunspot and in an undisturbed part of the photosphere. From these experimental intensities, it is deduced that the number of H atoms over a spot is nearly twice as great as over the photosphere.

The relative theoretical intensities of the lines of a multiplet may be obtained by the application of the sum rule of Burger and Dorgelo which predicts for the Mg triplet the ratio of 5 : 3 : 1. The total absorption

$= k\sqrt{NH_f}$ or $k'.NH_f$ according as the Doppler broadening is small or large.

The present observations show conclusively that Fraunhofer multiplet intensities depart greatly from the square root law. Probably this disagreement is due to self-reversal interlocking and complex structure of the lines.

A full description and discussion will be published later in K.O.B.

35. Studies in flame and arc spectra of copper salts.

NAND LAL SINGH, Benares.

The visible and ultra-violet spectra of the following copper salts have been studied:—

(i) The chloride, nitrate and sulphate in the D.C. 220 volt arc between copper electrodes, in the ordinary Bunson flame and in the blow-pipe flame.

(ii) The bromide, iodide and oxides in the Bunson and in the blow-pipe flame.

The chloride, bromide and iodide give their characteristic discrete band spectra as well as the well-known bands in the red generally attributed to CuO, under all the conditions of excitation mentioned. The nitrate, sulphate and the oxides have no characteristic spectra. A notable feature of the flames spectra of the halides and of some of the other salts studied is the selective development of certain atomic lines of copper, e.g. $\lambda\lambda$ 5105, 4651, 3274, 3247 A.U. in the Bunsen flame and in addition $\lambda\lambda$ 5782, 5218, 2492, 2441 A.U. in the blow-pipe flame. All the substances except the cupric oxide show in both the flames a continuous band interspersed with narrow structure-like lines. The intensity of the bands falls in the blow-pipe flame compared to that in the ordinary Bunsen flame. A wave-number difference of about 270 cm.$^{-1}$ is common among the narrow structure-like lines. The continuous band starts with a definite long wave limit λ 5742 A.U. and degrades towards the shorter waves up to about λ 5100 A.U. This band has been observed previously by Eder and Valenta in the flame spectra of all the copper salts investigated by them. The characteristics of this continuous band and its probable origin in a loosely bound copper molecule are particularly discussed.

36. The Doppler effect in the higher order Balmer lines of hydrogen.

B. DASANNACHARYA *and* C. DAKSHINAMURTI, Benares.

The Doppler displacement in Balmer lines at H_β and H_γ by Dr. Das have shown that it is less pronounced in H_γ than in H_β. There is a higher limit to the energy of the positive rays above which the Doppler displacement remains constant until a value is reached which is nearly double. Thereafter for higher energies the Doppler displacement increases linearly with the velocity of the positive ray beam. The present paper extends the studies of the limiting voltages for the constancy of Doppler displacement to the $H\delta$ and $H\epsilon$ lines of hydrogen. The spectra have been obtained with the help of a 3-prism Steinheil spectrograph of high resolving power $f/3$; the Doppler displacements are correlated with $\sqrt{\nu}$ which is proportional to the velocity of the particles. The part played by the different radiant atoms having their origins to atoms, molecules, and triatomic hydrogen will be discussed.

37. The Doppler and retrograde effects in the resonance radiation of mercury (25·36 A°).

C. DAKSHINAMURTI, Benares.

The Doppler displacement has been investigated in the resonance radiation (25·36A°) of mercury between 1000–24000 volts. The Doppler displacement is linear between those voltages with respect to the velocity of the positive ray beam. But the retrograde positive rays of this line show normal Doppler effect up to a voltage of 10000 above which it remained constant. A Hilger medium size quartz spectrograph is used for obtaining these spectra and the dispersion of the wave-length of the resonance radiation was found to be just sufficient to enable the Doppler displacement to be separated clearly. It is interesting to note that the maximum Doppler displacement has to be measured from the edge of the undisplaced line and not from the centre. This difference is particularly noticeable when the displacements are very small.

Statistics

38. Statistical study of forty years' annual rainfall at Patiala.

L. D. MAHAJAN, Patiala.

The data have been collected from various sources. Various curves showing the variation of rainfall during the last forty years with respect to various factors have been drawn. The tables for three-yearly, five-yearly, ten-yearly, and twenty-yearly mean annual rainfall, the standard deviations and the coefficient of variability are given.

The study of these curves and tables indicate that the mean value of the annual rainfall on the whole is irregularly decreasing with time. The variation of rainfall is not periodic. The range of variation (0·39 to 92·72%) is fairly high. But the mean value of the coefficient of variability is only 27·57%.

The major rainfall during a year is in the months of July and August due to the south-easterly monsoons, while the months of April, May, October and November are fairly dry. The average number of days and hours associated with rainfall in a year are 43 and 255 respectively.

Technical Physics

39. A note on the use of a few baking shellac varnishes for coating graphite-on-glass high resistances in the laboratory.

G. N. BHATTACHARYA, Ranchi.

Glyptal lacquer coated high resistances made of graphite lines on pyrex glass rods have been successfully used in direct current amplifying circuits by a few workers. Similar resistances coated with a number of baking shellac varnishes have been examined by the writer of this note. The effect of keeping these resistances in atmospheres of different humidity has been studied and their values under varying voltages have been determined in order to see if they conform to Ohm's law. It has been found as a result of this investigation that varnishes composed of shellac and linseed oil fatty acids are generally very satisfactory for the purpose of coating these high resistances to protect them from atmospheric moisture.

40. D.C. conductivity of Indian vegetable oils.

C. S. Ghosh *and* S. Chakravarty, Calcutta.

This paper deals with the variation of D.C. conductivity with voltage and with charging time for different Indian vegetable oils. The method used for the measurement of conductivity was that of charging a condenser to a known voltage and noting the current passing through the condenser. A direct current amplifier modified after the method of Tatel was used for the measurement of very feeble currents of the order of 10^{-13} amp. The higher D.C. voltages were obtained by rectification of A.C. voltage with a Kenotron rectifier. The range of voltage used for the measurements was 2 volts to 12,000 volts per cm. For measurement of the changes in conductivity, the oil under test was first subjected to the high D.C. voltage after being degassed and dehydrated. The condenser immersed in the oil was next put in the amplifier circuit with 2 volts impressed at its terminals. It was found that in each case the conductivity at any impressed voltage decreases with charging time and becomes almost constant after about half-an-hour of charging. For all voltages the oil was charged for half-an-hour before measurements for its conductivity were made. It was observed that the conductivity decreases with increasing values of impressed voltage and then becomes constant. The limiting value of this impressed voltage is different for different oils tested. For comparison, the conductivity of the oils was measured with an A.C. voltage of 50 cycles/sec. In this case there is, however, no change in conductivity either with change in the charging time or with increase in the charging voltage.

41. Daylight illumination values at Calcutta.

C. S. Ghosh, Calcutta.

The seasonal and daily variations in the daylight illumination at Calcutta have been measured by the visual photometric method for a period of one year from October 1939 to September 1940. After eliminating the irregular variations due to clouds, etc., the average monthly values of daylight intensity have been obtained. The maximum value of intensity is obtained in June and the minimum during December-January. The average values of intensity in the morning, noon and afternoon in June are respectively 7,300 ft.-candles, 4,500 ft.-candles and 5,450 ft.-candles; the corresponding values in December-January are respectively 3,500 ft.-candles, 2,500 ft.-candles and 2,400 ft.-candles.

Comparing these values for Calcutta with the data available for other places, notably for London, it is concluded that the values of daylight intensity are mainly determined by the altitude of the sun, the latitude of the place having no direct effect except in so far as the altitude of the sun at any place is related with its latitude.

Further, the apparent irregular variations in daylight have been explained as due to the presence of different types of cloud and their positions in the sky as well as to the presence of various scattering centres such as dust particles, etc.

More exact informations about the values of intensity can be obtained by extending the observations over a much longer period. The work is being continued in this laboratory.

42. The optical hygrometer.

L. D. Mahajan, Patiala.

A new apparatus has been devised for measurement of humidity of the air and comparison of the hygroscopic properties of soils and powders inside a laboratory, which proves more sensitive than the other methods.

It consists of a brass circular rod about 10 cm. long and 2 mm. thick, resting on two loose screws at its ends. Another rod of aluminium, 8 cm. long and 2 mm. thick is rigidly fixed at right angles to it in the centre. It has a cup of 10 mm. × 10 mm. × 2 mm. size on its each end. Just near its mid-point, an optical mirror is attached. A beam of light is thrown on this mirror and the reflected beam falls on a vertical scale at a distance of about 200 cm. from it. The whole instrument is enclosed inside a glass box having a base perforated with holes.

One cup is filled with a sample of soil and the other with quartz powder. When they are exposed to the moist air, the soil absorbs moisture while quartz remains unaffected. The motion of the spot of light is noted which is proportional to the quantity of moisture absorbed by the soil. Its absolute and comparative values can be calculated, and the humidity of air can also be known.

43. An electrical call and reply signal board for use in houses and offices.

A. C. Sehkar, Waltair.

A new design of a signal board has been worked out so that visitors may ring up any person mentioned on the board. The person, who has thus been rung up, sends one or other of a set of stock replies that are usually employed on such occasions. The replies depend either on the time of the visit or on the convenience of the person wanted.

The design is worked to ensure a minimum consumption of power. The mechanical and electrical details are discussed in the paper. It is hoped that the design will prove attractive to all busy persons for whom the necessity of such transference of stock messages is often felt essential.

44. Sensitization of Geiger point counters.

B. Dasannacharya *and* N. Adinarayana Murti, Benares.

The sensitiveness of a point counter depends on the nature of the needle tip. What exactly should be the tip has been discussed by Geiger at some length in his articles on Counters in Geiger-Scheel series of books on Physics. The practical working of these presents several interesting features which will be discussed. The retention or loss of sensitivity under various conditions of temperature, pressure, size and nature of tips, etc., will be discussed.

X-Rays and Crystal Structure

45. Patterson Fourier summation method of determination of the structure of metadinitrobenzene.

K. Banerji *and* M. Ganguly, Dacca.

Attempts to determine the atomic arrangements in metadinitrobenzene by the two-dimensional Fourier summation method in which the signs of the structure factors have been determined by the trial and error method has been found to be unsuccessful. This is apparently due to the uncertainties in the adopted atomic structure factors of nitrogen and oxygen in this compound. So to determine the signs by a direct method the interatomic vectors have been determined by the Patterson Fourier summation method according to the formula

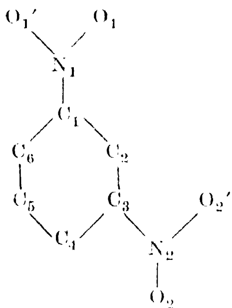
$$A(x, y) = \sum_h \sum_k F^2(hko)e^{2\pi i\left(\frac{hx}{a}+\frac{ky}{b}\right)}.$$

Due to the symmetry of the crystal, summation over only a quarter of the cell of sides $a/2$ and $b/2$ is necessary. Lines of equal Patterson densities were drawn and the peaks thus obtained were correlated with the different interatomic vectors. From these interatomic vectors the following x, y co-ordinates of the atoms have been obtained for one molecule :

Atomic parameters.

Atom		x/a	y/b
C_1	.. .	0·146	0·224
C_2	.. .	0·237	0·174
C_3	.. .	0·237	0·076
C_4	.. .	0·146	0·026
C_5	.. .	0·055	0·076
C_6	.. .	0·055	0·174
N_1	.. .	0·146	0·329
N_2	.. .	0·303	0·023
O_1, O_1'	..	0·172	0·372
O_2, O_2'	..	0·386	0·033

The symbols for the atoms will be clear from the structural formula of meta-dinitrobenzene given below.



The positions of the atoms in the other three molecules in the unit cell may be obtained from those of the above by determining the equivalent positions corresponding to the space-group D_{2h}^{16} Pbnm.

46. The secondary K-absorption edges of iron compounds in solids and in solutions.

B. B. Ray *and* S. Sen, Calcutta.

The secondary K-absorption edges of iron in the pure metallic form, its oxide (Fe_2O_3), some of its compounds $Fe_2(SO_4)_3 9H_2O$, $Fe(NO_3)_3 9H_2O$, $FeCl_3 6H_2O$, and colloidal ferric oxide and also in aqueous solutions of different strengths of these compounds have been photographed and analysed by the microphotometer. Secondary structures of complex compounds of iron such as $K_4Fe(CN)_6$, $K_3Fe(CN)_6$ have also been obtained. Among many of the peculiarities observed, the following deserve particular attention :

(*a*) Though the primary K edge of iron shifts to the shorter wave-length side of the spectrum as one passes from the metallic form of the element to its compounds, the secondary structures of nearly all the solid compounds of iron show a similarity with the metal itself; the structures immediately near the K edge in the case of the complex compounds like

potassium ferro- and ferri-cyanides being, however, different from the rest of the compounds studied.

(*b*) The distances of the secondary maxima and minima in volts from the principal absorption edge are not exactly the same in colloidal Fe_2O_3 and in solid Fe_2O_3. The intensity distribution in the structures of the two cases is, however, different. Further, the position of the primary edge in colloidal solution has shifted to longer wavelength compared to that in the solid state and the width of the edge has also increased in the colloidal solution.

(*c*) The pure metallic form of the element shows a 'fine structure' within the primary edge itself.

(*d*) Extended secondary structures obtained with the solid compounds mentioned before are found to persist even in solution. The similarity of structures in all solid polar compounds of iron and in concentrated solutions (up to a conc. 1N) is really striking. It has been suggested that this resemblance is due to the fact that in concentrated solutions most of the molecules remain undissociated.

In the case of dilute solutions of strengths of the order of N/20 or below, the structures near the primary *K* edge are quite different from what has been observed in concentrated solutions. The secondary structures almost vanish while the primary edge becomes very prominent and broad and is shifted towards the longer wavelength side of the corresponding edge in solid compounds.

A qualitative explanation suggested for this observation is based on the fact that as the concentration diminishes the number of the neutral molecules also decreases and consequently the intermolecular attraction also diminishes. Thus at low concentrations there is a small number of neutral molecules and the number of dissociated ions is rather large. We are also to consider the effect of the distribution of the positively and negatively charged ions as contemplated by Debye. As a result of these considerations the peculiar effect in strong and weak solutions may be explained.

The idealized widths of the primary *K* edges of iron in solids and solutions have also been measured. It has been observed that so far as the compounds of iron in solid state are concerned, the pure metallic element shows the largest width, whereas in solid metallic compounds and in their aqueous solutions the solid has the smallest width.

47. X-ray study of selenium. (In the liquid and the colloidal state.)

B. B. RAY *and* K. DAS-GUPTA, Calcutta.

Liquid selenium at various temperatures, viz. from 220° to 430°C., has been studied by the X-ray diffraction method with a specially designed camera. A single broad band with a band-spacing much bigger than that of amorphous varieties was obtained. The density of liquid selenium at various temperatures was also accurately determined. It is found that with the rise of temperature the band-spacing of liquid selenium also increases. By plotting the band-spacing of liquid selenium against the corresponding temperature and the cube-root of the reciprocal of density against the temperature, two smooth curves of similar nature were obtained.

Selenium, in its colloidal state, has been thoroughly studied by the X-ray diffraction method. Colloidal solution prepared by us was fairly stable and coagulation occurs on addition of HNO_3. The solution is stable even when heated at 100°C. for several hours. Both heated and unheated solutions, when allowed to evaporate at the room temperature, form a sticky mass. Coagulum obtained with unheated solution gives sharp monoclinic pattern if the coagulation is effected at a very slow rate. On rapid coagulation, however, the precipitate gives on X-ray analysis faint indication of crystalline (monoclinic) pattern with superimposed band. Similar results are also obtained with previously heated solution, the

difference being that the coagulated specimen now gives purely hexagonal pattern.

The sticky sample, both from heated and unheated sol gives only one single broad band. The spacing of the band (4·07 A.U.) has the same value as that obtained in the case of liquid selenium, near its melting point, but does not correspond with that of amorphous varieties of selenium (3·5 A.U.). This essential similarity in the nature of the diffraction pattern of liquid selenium and colloidal selenium suggests that the arrangement of atoms in each colloidal particle of selenium is the same as that in the groups (cybotactic) present in the liquid selenium.

48. X-ray study of allotropes of selenium.

K. DAS-GUPTA, Calcutta.

It has been shown by Bradley that conducting metallic selenium is of hexagonal form; the structure of the non-conducting monoclinic variety has also been determined by Klug. Among the amorphous varieties, the most important is the vitreous form of selenium prepared by quenching boiling liquid selenium in ice-cold water. The other amorphous varieties known to the chemists are the red pptd. selenium and the colloidal selenium.

In our laboratory we have studied the transition of the monoclinic variety into the hexagonal form by the X-ray diffraction method and have found that the period of transformation depends on the temperature, e.g., at 120°C. it takes 1 hour, at 80°C. 15 days and at 65°C. more than 17 days are required for the transformation. The transition is monotropic.

The amorphous varieties soften even at 38°C. (the melting point of metallic selenium being 217°C.) and on X-ray diffraction analysis three broad bands coinciding in position and intensity with the three distinct groups of lines of the crystalline varieties are obtained. It has been found that the vitreous selenium devitrifies even at 38°C. and the devitrified mass gives crystalline pattern. The rate of devitrification and the transformation into the crystalline modification depends very much on the temperature. The surface of the sample of vitreous selenium supplied by Dr. Grippenberg preserved in his laboratory in Finland for seven years (the maximum temperature throughout the year being below 27°C.) when examined was found to be crystalline, while the internal portion of the sample gave diffuse broad bands.

It has also been shown that at a very low temperature the devitrified product is purely monoclinic, and at a high temperature it is purely hexagonal. There are intermediate temperatures at which both monoclinic and hexagonal varieties are produced.

Accurate measurements of the spacings corresponding to the bands, obtained with samples of vitreous selenium heated for different periods at 38°C., show that the band-spacing is a continuous function of the period of heating. Now as there is a regular growth of size of the crystallites present in vitreous selenium with the period of heating, it is clear that the band-spacing is a function of the size of the crystallites. Our experimental results thus satisfy the theoretical work of Lennard Jones, viz., that the lattice constant should be a function of the particle size. The band-spacing corresponding to the sample of amorphous selenium coagulated from the colloidal solution is 3·8 A.U., while that of the vitreous selenium heated for 60 hours at 38°C. is 3·4 A.U. only.

49. Characteristic *K* emission bands due to conduction electrons of elements 11Na—15P.

B. BHOWMIK *and* B. B. RAY, Calcutta.

Soft X-ray emission spectra of elements 11Na—15P have been studied in the *K* series from their pure elements, oxides and some alloys. A

vacuum spectrograph was used in which a concave gypsum crystal was utilized as reflection grating. It was observed that the spark lines of tht α-group suffer a shift towards short wavelength side along with the parene line. The relative intensity of the spark lines α_3 and α_4 is reversed in their oxides compared to that of element. The β group also suffers a shift due to chemical effect, but unlike the α lines the shift of the β lines from oxides is towards the longer wavelength with respect to the lines from the elements. The difference between the two lines β_1 and β_n—the line from the element and its oxides respectively, is found to be a constant in ν/R scale from 11Na up to the element 16S.

It was noticed that the metallic surface of the element is very easily oxidized during excitation due to electron bombardment. The metallic spectra therefore contain also the β lines from its oxides on the long wavelength side which Siegbahn denotes as β_1, and the metallic bands as β_x. The nomenclature has been interchanged to comply with experimental facts.

The β lines arise due to the transition of conduction electrons and have a remarkably large width. The widths have been measured in e.v. and compared with the previous experimental results and Sommerfeld's theoretical values. The agreement is satisfactory except in the case of Mg.

The structure of the β bands has been studied microphotographically. The metallic bands from Mg and Al show sharp emission edge on the short wavelength limit corresponding to the Fermi surface of the conduction electrons. A remarkable change in the structure of the band of Al occurs when the spectrum is excited by low voltage (2 K.V.). The bands from the non-conductors like AlO, MgO and mica show symmetrical structure without showing any sharp edge. The structure of the bands from the alloys resembles that of pure metal in the higher concentrations while in the dilute solid solutions it undergoes a radical change and the sharp edge disappears. The structures of the bands have been discussed in the light of various conduction theories due to Bloch, Pierles, Brilouin and others.

50. Fluorescence of organic compounds by X-rays.

B. B. Ray, H. Bose *and* K. Das-Gupta, Calcutta.

Newcomer observed that many organic substances fluoresce when exposed to X-rays and attempted to find some use of it in medical therapy.

It has been observed in our laboratory that benzene, naphthalene, anthracene, phenanthrene, camphor, carbazole and several other aromatic compounds produce very strong fluorescence in the visible region when excited by X-rays. Compounds like cyclohexane, cyclopentane, etc. do not fluoresce. It may be mentioned here that most of the substances which produce fluorescence under X-ray irradiation also develop fluorescence under ultra-violet radiation and the positions of the luminous bands (from X-rays) are almost the same as those excited by ultra-violet light. Preliminary observations on the positions and intensities of these luminous bands have been made by a direct vision spectroscope provided with a wavelength scale.

For a detailed study, photographs of the fluorescence bands with a Fuess spectrograph and their microphotometer records have been taken. Several bands separated by small dark spaces were obtained. Anthracene gives three bands having maxims at 5709, 5324, 4966 A.U., while naphthalene produces three bands, diphenyl five, fluorene six and so on.

The positions of the bands and their intensities are found to change with ortho-, para- and meta-varieties of the same compound. The position of the band also varies with the α and β variety, e.g., the band maxima of α-naphthol is 470 $\mu\mu$, β-naphthol is 500 $\mu\mu$.

Diphenyl and naphthalene are both formed by the union of two benzene nuclei, but diphenyl is a multinuclear compound and naphthalene

is a condensed nuclear compound. It has been observed that if we give a shift of the order of 70 A. U. towards the longer wavelength side, to the spectra of diphenyl, the three bands of diphenyl coincide with the corresponding spectra of naphthalene.

The introduction of different chemical groups in the aromatic compounds and the corresponding change in the fluorescent radiation are interesting. Carbazole and fluorene are both derivates of diphenyl; in carbozole we have a CNH group and in fluorene we have a CH_2 group in the corresponding position. Experimental results show that, as a result of the introduction of CNH group in carbazole in place of CH_2 group in fluorene, the spectra of carbazole shift towards higher frequencies. Changes in the colour of fluorescent radiation and also in the colour of the samples are observed in certain compounds, e.g., naphthalene when exposed for more than half an hour under X-rays, the colour of fluorescent light changes to a colour similar to that of the fluorescent light of anthracene; the colour of the sample of white naphthalene also changes to yellow.

Of all the compounds tried by us only triphenyl methane exhibits phosphorescence under X-rays. The substance is found to show an afterglow for a period of 40 seconds approximately when the X-ray radiation is cut off.

51. An X-ray investigation of tellurium in the solid, liquid and colloidal state.

H. BOSE, Calcutta.

The X-ray diffraction method was employed to study the different allotropic modifications of tellurium. Precipitated tellurium, previously supposed to be amorphous, was found to consist of hexagonal crystals in a finely divided state. The effect of temperature on tellurium was also investigated with the result that no indication of any other crystalline variety of tellurium could be detected so that it seems unreasonable to maintain the idea that ordinary tellurium consists of two dynamic allotropes in thermal equilibrium as was held previously and contended recently by Damiens. Under X-ray exposure specific heat of tellurium changes by as much as 8% and this was attributed to a change in crystal structure but no such effect could be detected in the present investigation.

The usual method of preparing vitreous state was tried for tellurium without success; and amorphous variety or any other variety of tellurium could not be prepared by any of the known methods.

In a specially designed camera tellurium was examined in the liquid state. Liquid tellurium produced a single band of spacing (3·1 A.U.).

With a view to obtain informations regarding the nature of colloidal particles with special attention to their changes due to slow coagulation in ageing, tellurium sol was coagulated in different ways and coagulum examined by X-rays. The coagulum from a freshly prepared tellurium sol by nitric acid was found to be amorphous, while the diffraction pattern of the coagulum of aged sol pointed to the existence of a new variety of tellurium.

52. Sulphuric acid at different concentrations by X-ray diffraction method.

H. BOSE, Calcutta.

In the present investigation, X-ray diffraction of pure acid and at concentrations corresponding to the formulae H_2SO_4, H_2O; H_2SO_4, $2H_2O$; H_2SO_4, $3H_2O$; H_2SO_4, $10H_2O$; H_2SO_4, $20H_2O$, etc., was studied Pure sulphuric acid yields two well-defined bands (spacings 4·07 and 7·98 A.U.) with very little general scattering thereby following the general behaviour of highly associated liquids, though the inner band remained undetected so long. With dilution the main band dilated and at the

same time underwent an increase in diffuseness till at high dilution the familiar band of water made its appearance and the main peak of sulphuric acid nearly coincided with the first band of water (3·24 A.U.). Considering the main peak at larger angle at any dilution, the spacing of the acid was found to be intermediate between those of pure sulphuric acid (4·07 A.U.) and pure water (3·24 A.U.). The spacing undergoes a violent change when the concentration is changed to H_2SO_4, H_2O and again at H_2SO_4, $20H_2O$. At other concentrations studied, the spacings remained nearly constant at 3·54 A.U. This may be taken as to indicate something akin to hydrate-formation. Sulphuric acid, it is known, ionizes in aqueous solution in two stages. But apart from making the bands a bit diffuse, this was found to have little effect on the X-ray diffraction pattern. This is but what can be expected, for (SO_4^{-}), (HSO_4^{-}) and (H_2SO_4) have almost the same dimension and scattering due to H^+ is negligible.

SECTION OF CHEMISTRY

President :—MATA PRASAD, D.Sc., F.N.I.

Inorganic Chemistry

1. Sulphuryl iodide.

M. R. ASWATHA NARAYANA RAO, Bangalore.

Spectroscopic investigations show that sulphuryl iodide is produced by the action of potassium iodide on a dilute solution of sulphuryl chloride in carbon disulphide at $-70°C$. At the laboratory temperature, the iodide decomposes almost immediately into sulphur dioxide and iodine which on cooling do not recombine.

2. Selenium iodide.

M. R. ASWATHA NARAYANA RAO, Bangalore.

The existence of selenium iodide has been a controversial subject. The author has shown that the compound is produced when a dilute solution of selenium chloride in carbon tetrachloride is shaken with dry potassium iodide. The iodide is highly unstable in presence of light and decomposes into selenium and iodine. The hydrolysis of selenium iodide by water has been investigated. Decomposition of selenium iodide has been studied spectroscopically.

3. Investigations on the chemical behaviour of sulphur compounds Part III. Reaction between sulphur dioxide and hydrogen sulphide.

B. SANJIVA RAO, Bangalore.

Sulphur dioxide and hydrogen sulphide are known to react at the surface of glass, producing sulphur and water. The author has studied the effect of moisture, carbon tetrachloride, mercury, aluminium chloride, and phosphorus pentoxide on the catalytic influence exercised by the glass surface. The results can satisfactorily be interpreted on the basis of the formation of an activated complex of the two gases, in association with water.

4. Physico-chemical investigations on Bordeaux mixture.

G. NARAYAN *and* B. SANJIVA RAO, Bangalore.

The aqueous phase in contact with freshly prepared Bordeaux mixture (5 : 5 : 50) contains 6 to 7 mg. per litre, of copper. On keeping the copper content of the solution falls and attains a steady value of 0·54 mg.

The calcium hydroxide and calcium sulphate present in the supernatant liquid have a profound influence on the copper content of the solution. The effect on Bordeaux mixture of the removal of the sulphate and of the hydroxide from the solid phase is discussed.

Freshly precipitated copper hydroxide has been found to adsorb calcium hydroxide and calcium sulphate from a saturated solution

containing both these compounds yielding finally a deep blue solid having the same solubility as the Bordeaux solid.

The constitution of Bordeaux mixture is discussed in the light of these observations.

5. Complex compounds of phenylbiguanide with copper and nickel, and their *cis-trans* isomerides.

PRIYADARANJAN RÂY *and* KSHITISH RANJAN CHACKRABARTY, Calcutta.

Copper phenylbiguanide dihydrate has been isolated in two forms—α and β, coloured light blue and rose-red with m.p. 155° and 165°C. resp. The molecular weight of the anhydrous compounds determined by the ebullioscopic method indicates their monomeric nature. The hydrochloride of the complex base has also been prepared in two modifications α and β. The α-form crystallizes with $6H_2O$, has violet colour and melts at 170°C. The red coloured β-form contains $3H_2O$, melts at 216°C. and is much less soluble than the α-form. In presence of steam the α-variety changes into the β-form at 101°C. In solution the β-variety readily gives rise to colloidal aggregates. From a consideration of their properties it is assumed that α- and β-forms are related as *cis-trans* isomers corresponding to the different positions of the phenyl groups in a four co-ordinated planar structure. Other salts of the complex base, such as bromide, iodide, sulphate, dithionate, nitrate and nitrite have also been prepared in two different forms. Besides these, the preparation and properties of many other salts, e.g., thiocyanate, thiosulphate, sulphite, chlorate, bromate and iodate have been described.

Nickel phenylbiguanide has been obtained in three forms—α, β and γ. The brick-red α-form crystallizes with $\frac{1}{2}$ mol of water and decomposes at 255°C. The anhydrous light yellow β-form decomposes at 265°C. The yellow crystalline γ-variety contains $\frac{1}{2}$ mol of H_2O and decomposes at 263°C. The α-form is easily soluble in alcohol or acetone, but readily separates out in the form of yellow γ-variety. The β-form is insoluble in these solvents. α and β are probably related to each other as *cis-trans* isomers like the corresponding copper compounds. γ is possibly a mixture of the two.

Various salts of nickel phenylbiguanide, e.g., chloride, bromide, iodide, nitrate, nitrite, dithionate, sulphate, sulphite, thiosulphate, thiocyanate, chlorate, bromate and iodate have been described. None of these salts have, however, been obtained in two modifications.

6. Co-ordinated nickel compounds with benzidine.

KANAI LAL MANDAL, Calcutta.

Nickelous salts such as nickel sulphate form with benzidine chelate compounds, in which two molecules of benzidine combine with a molecule of the nickel salt. The *cis*-benzidine nickel compounds are insoluble in water but dissolve somewhat in alcohol. They appear to be co-ordinately saturated. For though they dissolve in pyridine, piperidine and other organic amines, they do not take up further addenda of co-ordination. Only the original nickel benzidine compounds precipitate out on addition of water to their amine solutions.

7. On the formation of complex silicate ions.

R. C. RAY, P. B. GANGULY, *and* A. B. LALL, Patna.

W. L. Bragg (*Trans. Faraday Soc.*, 1929, **25**, 291) has shown that the structure of the silicates may be regarded as based in all cases on the

formation of co-ordination lattices of large anions about small cations. Goldschmidt (*Ber.*, 1927, 60, 1263) has shown that the co-ordination number of a cation in such a structure is governed solely by the relative radii of the central cation and the surrounding anions. From the chemical point of view the anion of the whole lattice will be an assembly of oxygen ions with the silicon ions co-ordinated between them, so that in the formation of the silicates the following possible types arise:—

$$SiO_4^{4-}; Si_2O_7^{6-}; Si_3O_9^{6-}; Si_6O_{18}^{12-}; SiO_3^{2-}; Si_4O_{11}^{6-} \text{ and } Si_2O_5^{2-}.$$

The present work was undertaken to obtain, if possible, direct evidence of the formation of these complex ions and the rates of diffusion of the sodium silicate solutions having the ratio of $SiO_2 : Na_2O$ as 2 : 1 and 3 : 1 have been studied. Some evidence of the formation of complex silicate ions has been obtained. It has also been found that the hydroxyl ions diffuse at a rate which is quite different from the rate of diffusion of the silicate ions so that the OH^- ions do not seem to enter into the composition of the complex.

Further work with silicate solutions of different ratio is in progress.

8. A study of the complexes of $HgCl_2$ with KI in aqueous system.

S. S. Joshi, D. N. Solanki, *and* B. G. Joshi, Benares.

A study of the complexes of mercuric chloride with potassium iodide in aqueous system has been made, at temperatures 15° and 30°C., by conductivity, viscosity and refractivity measurements. The mixed systems studied consisted of varying proportions of mercuric chloride in the presence of fixed concentration of KI $\left(\frac{M}{20} \text{ and } \frac{M}{50}\right)$. The maximum concentration of $HgCl_2$ added was such as to avoid the actual precipitation of HgI_2. Specific conductivities of the mixed systems and constituent solutions were separately determined. Viscosity and refractivity measurements of these mixed solutions were also made at the specified temperatures. The minima in specific conductivity-, maxima in viscosity-, and minima in refractivity-composition curves, were taken as indicative of complex-formation, and the composition of the complex formed being noted from the composition corresponding to the position of minima or maxima in the respective curves. All measurements lead to the existence of a complex of KI and $HgCl_2$ in the molecular porportion, 10KI, $HgCl_2$ at 30° and 20KI, $3HgCl_2$ at 15°. Our data also show an indication of another break in the respective curves corresponding to a point in the vicinity of maximum concentration of $HgCl_2$ tried, roughly corresponding to a formula, 4·5 KI, $HgCl_2$. The breaks in the respective curves are sharp and well defined, especially in concentrated solution and at low temperatures thus showing that the complexes formed in the aqueous system dissociate at high temperature and dilution.

9. New compounds of gallium : Part IV. Double sulphates of gallium and primary, secondary, tertiary amines and quaternary ammonium bases.

P. Neogi *and* Kanai Lal Mandal, Calcutta.

Several double sulphates of gallium and primary, secondary, and tertiary amines and tetramethyl ammonium hydroxide have been prepared.

10. Decomposition of mixtures of calcium chromate with magnesium oxide.

D. S. DATAR *and* S. K. K. JATKAR, Bangalore.

The mixtures of two mols of calcium chromate with one mol of magnesium oxide decomposed with the initial formation of a basic chromate, in successive stages at 25, 33·3, 40 and 50% decomposition of the chromate.

The decomposition of mixtures of strontium chromate with magnesium oxide indicated formation of the basic chromate 8SrO, 4MgO, $8CrO_3$.

11. Thermal decomposition of nitrites.

M. S. SHAH *and* K. M. MEHTA, Ahmedabad.

With a view to elucidate the mechanism of the decomposition of nitrites in general, the authors have carried out a detailed quantitative study of (A) the thermal decomposition of (i) potassium nitrite and (ii) silver nitrite, (B) the effect of nitrogen dioxide on (i) potassium nitrite and (ii) silver nitrite, silver oxide and silver, and (C) the effect of nitric oxide on (i) potassium nitrite and potassium nitrate and (ii) silver nitrite, silver nitrate, silver oxide and silver.

Experiments were conducted (*a*) at various temperatures, (*b*) for different periods of time, and (*c*) with varying amounts of the substance.

A mechanism of the reactions has been put forward. It shows that the decomposition of potassium nitrite leads to the production of K_2O, KNO_3, NO_2 (in traces), NO and N_2, while the decomposition of silver nitrite proceeds giving rise to $AgNO_3$, Ag, NO_2 (in traces), NO and N_2 (in traces). The differences observed in the products of the two decompositions is due to the difference in the stability of K_2O and Ag_2O towards nitric oxide.

12. On 'Precipitation' hardness of some coinage alloys.

G. C. MITTER *and* B. K. BOSE, Bombay.

Coinage alloys of gold, silver and nickel with copper were studied with a view to elucidate their structures and correlate them to their properties. Slowly cooled alloys of the above descriptions revealed a coarse lamellar structure similar to pearlite in steel due to the progressive separation of the less soluble element at lower temperatures from the α-solid solution. This structure was not conducive to cold work. But when annealed at high temperature so as to obtain the α-solid and quenched rapidly in cold water, resolution was arrested and a super-saturated α-solid solution was obtained. Associated with this structure was the property of extreme malleability and had obvious advantages for skilful fabrication. With suitable heat treatment and subsequent quenching of this super saturated α-solid solution, a wide range intermediate hardness was obtained suitable for different types of work.

13. Action of charcoal on potassium nitrate.

T. M. OZA *and* M. S. SHAH, Ahmedabad.

With a view to throw light on the reactions taking place during the combustion of gunpowder, the action of charcoal on potassium nitrate has been studied in detail. Series of experiments were conducted with (A) charcoal and potassium nitrate, (B) charcoal and potassium nitrite, and (C) charcoal and mixtures of potassium nitrate and potassium

nitrite, under varying conditions of temperature, pressure, time, mass of the reactant, etc., and analyzing the solid and gaseous products at the end of each experiment.

Experiments in (A) showed that the reaction at about 250° leads to the production of potassium nitrite and carbon dioxide. With rise in temperature, this process is accelerated and the nitrite interacts with more charcoal until at 390° a violent reaction ensues accompanied in certain circumstances by a flash. A quantitative study of the effect on flash production of accumulated gaseous products or alternatively of removing these gases either partially or completely showed that at the flash stage, nitrogen and carbon dioxide are produced in equal volumes, a proportion which corresponds with the reaction of charcoal with molecular proportions of potassium nitrate and nitrite.

Experiments in (B) showed that the reaction which occurs at about 390° is always violent and comes to an end without the production of a flash, the main products of the reaction being potassium carbonate, nitrogen and carbon dioxide.

Experiments in (C) showed that the production of a flash is accelerated by increasing the amount of the nitrite and when the two salts are in molecular proportions the flash is likely to be observed instantaneously. At this stage, the reacting mixture evolves nitrogen and carbon dioxide in equimolecular proportions. During the violent stage of the interaction some carbon monoxide which is likely to be formed would react with oxygen or nitrogen dioxide producing the flash.

The probable mechanism of the (I) initial, (II) smooth, and (III) violent stages of the interaction between charcoal and potassium nitrate has been suggested.

Physical Chemistry

14. Apparent molal volume of electrolytic mixtures in aqueous solutions.

A. S. CHACRAVARTY *and* B. PRASAD, Cuttack.

Redlich and Rösenfeld showed on theoretical considerations that apparent molal volume (ϕ) of electrolytes in solution should be a linear function of the square root of concentration (c). They also showed that 'k' in the equation $\phi = \phi_0 + k\sqrt{c}$ should be dependent on the valence type of the salt only. A large number of workers have thrown doubts on the linearity at very low concentrations. It has also been definitely shown that 'k' is not the same for the various salts of the same valence type. However, there is no doubt that ϕ is linear with $\sqrt{c}$ at concentration above 0·01 molal.

It was considered worthwhile to examine the behaviour of mixtures of electrolytes whose total concentration (c) was greater than 0·01 molal. The apparent molal volume is calculated from the usual formula

$$\phi = \frac{M}{} - \frac{1000(\rho - \rho_0)}{},$$

the molecular weight of the mixture of electrolytes being taken to be $\frac{c_1M_1 + c_2M_2}{c, \text{ i.e. } (c_1 + c_2)}$. It is found that if $c_1 : c_2$ is kept constant, i.e. if the average molecular weight is not changed Redlich-Rösenfeld Law is obeyed by mixtures of electrolytes also. The change of ϕ with change in ratio of c_1 and c_2 is regular. In fact ϕ is a linear function of fractional molal concentration, i.e. $\frac{c_1}{c_1 + c_2}$.

15. Kinetics of reactions in heterogeneous systems. Part VII. Liquid-liquid systems.

D. D. KARVÉ *and* K. K. DOLÉ, Poona.

The influence of concentrated solutions of neutral electrolytes like sodium sulphate on the velocity of hydrolysis of acid chlorides in liquid-liquid systems is that of retardation which is attributed to the change in the adsorption process at the surface of contact. Addition of the electrolyte causes a diminution in the concentration of the acid chloride adsorbed at the surface of the non-aqueous phase and an increase in the temperature coefficient of the reactions. The increased temperature coefficient does not exceed the temperature coefficient of the chemical process. There is no increase in the temperature coefficient of those reactions in which the diffusion process has no influence on the rate of reaction.

16. Studies in the kinetics of consecutive reactions: hydrolysis of nitriles.

D. D. KARVÉ *and* M. G. PURANDARE, Poona.

The velocity of hydrolysis of acetonitrile, propionitrile and butyronitrile by aqueous sulphuric acid of 20N strength has been studied at different temperatures between 50° and 90°. It is observed, that propionitrile is hydrolyzed more rapidly than acetonitrile under the same conditions. The temperature coefficients of the reaction vary to a certain extent with temperature and there are also small differences between the coefficients for different nitriles at the same temperatures.

17. Velocity of hydrolysis of anilides by acids.

D. D. KARVÉ *and* P. V. CHAUDHARI, Poona.

It has been observed that the hydrolysis of acetanilide and propionanilide dissolved in 50% alcohol by aqueous sulphuric acid is a reaction which can be fairly well represented as a monomolecular reaction. The former gives constant values for K while in the case of propionanilide the values at first increase and later decrease to a certain extent. Other anilides are being investigated.

18. Deformation of polar crystals in glass systems.

SUBODH KUMAR MAJUMDAR *and* ASEEM KUMAR SARMA, Calcutta.

An attempt has been made to measure the deformation produced in such polar crystals as LiCl, NaCl, KCl, RbCl and CsCl when dissolved in B_2O_3-glass. The effect of concentration on the deformation has also been studied. Isotropic glasses of B_2O_3 containing varying amounts of the salts were prepared by melting the substances, previously dehydrated as far as possible, in an electric furnace at a temperature of about 1000°C. and allowing the melt to cool slowly. The alkali chloride content was estimated by the sulphate method. The density was determined by a slightly modified flotation method, previously employed by Wulff and Majumdar (*Z.f. physikalische Chemie*, 1936, *B*, **31**, 319). The refractive index of the glasses in D-light was determined by suspending them in a liquid mixture of approximately the same refraction. On varying the proportion of the liquids and examining the Becke-effect two mixtures

were obtained, one in which the Becke-lines just penetrated into the glass and the other, in which the lines just receded, when the microscope objective was raised. The liquid mixtures were then examined in a Pulfrich refractometer and the mean value of the refractive index was taken. Generally, the two values showed a variation in the fourth place of decimals, which for solids may be regarded as satisfactory. The mole-refraction was first calculated from the well-known Lorenz and Lorentz formula and then from the additive formula. Any deviation from the additivity relation would point to deformation of the particular constituent.

The experimental results show that the polar crystals are quite strongly deformed in B_2O_3-glass and the deformation follows the same approximate order as in strong aqueous solutions of these salts (Fajans and his co-workers). The results therefore go strongly against the researches of Biltz and co-workers and seem to support the recent work of Korde. The well-known Fajans-deformation rule holds good *qualitatively* in glass systems as well, and the following inequality

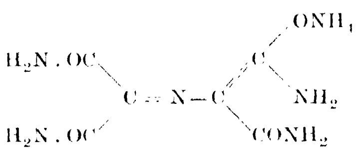
$$Li > Na > K > Rb > Cs$$

is found to be true, in keeping with the assumptions of the Fajans' Theory.

19. Absorption spectrum of violit, an open-chain analogue of murexide.

D. D. Karvé *and* K. K. Dolé, Poona.

A compound was obtained by Karvé (*J. Univ. Bom.*, 1931, **1**, part 2, 48) by the action of ammonia on a mixture of mesoxalic and tartronic esters to which he had assigned the following structure



and named it *violit* on account of its deep violet colour. In chemical behaviour this compound resembles murexide, which has also a similar structure containing alternate single and double bonds and is deeply coloured. It has been observed that their absorption spectra are similar in general shape, although there are minor differences in the width of the band and the position of the head.

20. Investigation of photochemical after-effect Part III. Decomposition of hydrogen peroxide by sodium nitroprusside.

Bijan Behari Lal, Lucknow.

Further experimental observations on the photochemical after-effect in the decomposition of hydrogen peroxide by sodium nitroprusside in visible light have been made. The chemical mechanism of the after-effect has been pictured as follows:—

$$Na_2Fe(CN)_5NO + H_2O \xrightarrow{\text{Light}} Na_2Fe(CN)_5H_2O + NO.$$

Sodium aquopentacyanoferrate whose formation is demonstrated continues its catalytic influence in the dark. When potassium ferrocyanide is added to an illuminated solution of nitroprusside in the dark, the following reaction takes places:—

$$Fe(CN)_5H_2O''+Fe(CN)_6'''' \longrightarrow Fe(CN)_5H_2O'''+Fe(CN)_6'''.$$

Sodium aquopentacyanoferrite causes the rapid decomposition of hydrogen peroxide, thus accounting for a higher value of the unimolecular constant in the presence of potassium ferrocyanide in the pre-illuminated mixture of hydrogen peroxide and nitroprusside in the dark.

A crucial test of the validity of the suggested scheme for the after-reaction is provided by the influence of cyanide ions. The latter have been shown to suppress the after-effect by converting the aquoferrite to ferrocyanide,

$$Fe(CN)_5H_2O'''+CN' \longrightarrow Fe(CN)_6''''+H_2O.$$

Sodium aquopentacyanoferrate prepared in the pure state and added to hydrogen peroxide nitroprusside mixtures in the dark in the presence and absence of ferrocyanide has been shown to reproduce the results obtained by illumination. The effect of variation in the concentrations of nitroprusside, ferrocyanide, and aquoferrate has been investigated and explained.

21. Photosensitization by cadmium oxide.

G. Gopala Rao, Waltair.

Cadmium oxide has been found to be a good photosensitizer for (1) the decomposition of silver nitrate in aqueous solution, (2) the decolorization of dyes, (3) the formation of hydrogen peroxide, and (4) the oxidation of ammonia. Experimental results are given.

22. Raman effect of cresyl-methyl and cresyl-ethyl ethers.

N. S. Krishnaswami *and* S. K. K. Jatkar, Bangalore.

The light scattering of *o*-, *m*- and *p*- cresyl-methyl and cresyl-ethyl ethers has been studied with a view to explain the difference in their chemical reactions.

23. Thermal conductivity of active nitrogen.

S. S. Joshi *and* A. Purushottam, Benares.

This has been studied by the 'cooling thermometer' method by an accurate determination of the time-rate for the temperature fall for several temperature intervals in the range 40 to 90° in streams of well-dried air, nitrogen and active nitrogen, which were streamed at various pressures in the range 5 to 60 mm. Hg., the rates of flow being varied up to over 40 fold. The pressure-conductivity curves for any of the above gases in the range of conditions mentioned showed three fairly distinct sections. At small pressures the conductivity increased rapidly with the gas pressure; it was sensibly independent of the pressure for medium values of the latter; increased with pressure in the last stage when pressures were large. During the first and second sections, where the conditions are comparatively simpler in respect of the mechanism of heat conduction in gases, it has been found that active nitrogen shows a definitely higher

conductivity for heat than ordinary nitrogen under identical conditions. This is perhaps deducible from the Wiedemann-Franz law since Rayleigh has found that the electrical conductivity of active nitrogen is markedly high. Our results are in agreement with the hypothesis that active nitrogen consists of a mixture of 'activated' molecules and atomic nitrogen (*cf.*, Langmuir, *J. Amer. Chem. Soc.*, 1912, **34**, 860; Senftlehen and co-workers, *Phys. Z. it.*, 1930, **31**, 822, 961; *Ann. der. Phys.*, 1933, **16**, 907). At high pressures the conductivity of active nitrogen has been found to be lower than that of ordinary nitrogen; this has been traced, in part, to a number of extraneous circumstances which mark the main phenomenon such as the convection currents, the sensibly exothermic deactivation of active nitrogen at high pressures, etc.

24. Studies of luminescence due to active nitrogen.

S. S. Joshi, K. Lakshmana Murty, *and* M. S. Deekshitulu, Benares.

As a preliminary to an exhaustive spectroscopic examination of the luminescences induced by leading active nitrogen over different types of chemical compounds, data have been accumulated in respect of about 450 inorganic and 200 organic substances exposed to active nitrogen. The stream of the glowing gas was allowed to play over a small copper spoon containing the material to be examined. The glows, which were too feeble to be noticed by this arrangement, were rendered brighter by exposing a fine film of the material freshly produced by evaporating its solution repeatedly on a plane glass receptacle. The liquids were examined by introducing at the appropriate stage in the evacuated system a blob of glass wool charged with the liquid.

These light effects, even on a mere visual examination, were found to be extremely diverse and characteristic of the specific material examined. Thus for instance, except those of ammonium and strontium, practically all the bromides examined did not show any characteristic luminescence. The silicates, hydroxides, arsenates, arsenites, chlorates, perchlorates, sulphides, carbonates, borates and tartrates of sodium and potassium glowed. Their permanganates, chromates and iodates are inactive. It is remarkable, however, that while sodium chloride glows, the corresponding potassium salt does not.

The sulphates of alkaline earth metals, of lead and copper glow but not their persulphates. All halides of the alkaline earths (except perhaps those of beryllium), their carbonates and oxides glow. The borates of the alkaline earths do not glow; those of the alkali metals showed strong luminescence. The glows were normal in the case of phosphates of strontium, barium, ammonium and lead. That of cadmium wolframate is brilliant. Lithium carbonate comes next.

Practically all the salts examined hitherto in the case of tin, bismuth, antimony, nickel, manganese, cobalt, chromium, iron (except ferrous phosphate) and mercury (except mercurous chloride) do not glow.

In previous experiments in these laboratories the utilizability of iodine as a sensitive detector of active nitrogen has been reported already. The colour of the entire after-glow in the observation tube containing the small iodine receptacle changes to blue almost immediately after the active nitrogen is admitted. This has been traced to the presence of iodine vapour in the observation chamber. That simple sublimation is not the sole factor is indicated by the fact that the migration of the iodine vapour is sensibly less in absence of active nitrogen.

Calcium sulphate glow, when examined over a plane glass film, showed a marked heterogeneity in the distribution of the intensity.

Amongst organic substances fluoranthene chrysen, indol, starch, carbazole, sodium benzoate, nephthalene-sulphonic acid and β-methyl

anthracene showed a pronounced luminescence. Naphthalene, diphenyl, urea, dextrin, fumaric acid, oxalic acid, aniline brown, eosin, yeast, etc., are inactive. In organic compounds the colour of the luminescence depends more on the nature of the exposed material than in the case of inorganic substances. Thus for example carbazole glowed light pink; phenanthrenquinone brownish red, and indole pale yellow. A majority of the bromo- and chloro-compounds were found to be inactive.

25. Vapour pressures of hydrochloric acid in benzene and solutions of phenolic ethers in benzene.

N. L. PHALNIKAR, S. P. WALWEKAR, *and* B. V. BHIDE, Poona.

The method of Saylor (*J.A.C.S.*, 1937, 1712) for determining the vapour pressures of hydrogen chloride in benzene, has been modified. In the modified apparatus equilibrium between vapour and the solution is rapidly attained and a determination does not take more than an hour. Vapour pressures of hydrogen chloride in benzene have been determined at 25°. The results are in agreement with those of O'Brien, Kenny and Luercher (*J.A.C.S.*, 1939, 2504) and Wynne-Jones (*J.C.S.*, 1930, 1064).

Vapour pressures of hydrogen chloride in solutions of anisole, hydroquinone dimethyl ether and para-nitro-anisole in benzene have been determined for various concentrations. A marked depression in the vapour pressures is observed in the case of anisole, but there is no indication of an addition compound being formed. In the case of the other two ethers the vapour pressures are unchanged.

26. Magnetism and molecular structure.

MATA PRASAD *and* S. S. DHARMATTI, Bombay.

In continuation with our previous work organo-metallic compounds of Se, Te, and S have been investigated. It has been found that ionic values calculated according to Slater's and Angus's method together with Pascal's data give susceptibility values which are more in agreement with the experimental values than those in the case of inorganic compounds. The substances investigated so far are of the type $(CH_3)_2TeI_2$ and $(CH_3)_2TeCl_2$.

27. Magnetic susceptibility of barium ion.

MATA PRASAD, S. S. DHARMATTI, *and* C. R. KANEKAR, Bombay.

The ionic susceptibility of barium ion has been calculated in its natural valency state according to Slater's and Angus's method. The value according to Slater's method is $-33{\cdot}3 \times 10^{-6}$ and that by Angus's method is $-31{\cdot}5 \times 10^{-6}$. The value for the ionic susceptibility of barium ion given in the International Critical Tables is $-38{\cdot}2 \times 10^{-6}$. In order to examine this large discrepancy, the susceptibilities of several pure barium compounds were measured and the ionic susceptibility of barium ion was calculated therefrom. The observed results are in better agreement with the values calculated from Slater's and Angus's formulae.

28. Molecular orientations in crystals of diphenyl-disulphide and diphenylene-disulphide.

JAGDISH SHANKAR, Agra.

The crystals of diphenyl-disulphide and diphenylene-disulphide have been examined by the X-ray rotating crystal method by Jagdish, Prasad,

and Peermohemad (*J. Indian Chem. Soc.*, 1937, **14**, 184), Egartner, Halla, and Schacheri (*Zeit. f. phys. Chem.*, 1932, **18**, Abt. B, 2-3, p. 189,) and R. Wood (*Nature*, 1938, **142**, 257,). In the present investigation the magnetic anisotropies of the two crystals have been measured by the method of Krishnan. The principal gram molecular susceptibilities (10°) calculated from the above for the two crystals are as follows:—

Diphenyl-disulphide .. $\chi_a = -132{\cdot}7$, $\chi_b = -134{\cdot}3$, $\chi_c = -112{\cdot}5$

Diphenylene-disulphide .. $\chi_1 = -118{\cdot}4$, $\chi_2 = -161{\cdot}4$, $\chi_3 = -108{\cdot}2$, $\psi = 70°$.

The orientations of the molecular planes calculated from the above show that in diphenyl-disulphide the molecular planes are equally inclined to the *a* and the *b* axes and are inclined to the *c* axis at about 62°. In the case of diphenylene disulphide the above results show that the planes of the two benzene nuclei are inclined at about 140°, the line joining the two sulphur atoms is inclined at about 30° to the *b* axis and the general direction of the molecule makes an angle of about 40° with the *a* axis.

29. Crystalline structure of *p*-azotoluene.

JAGDISH SHANKAR, Agra.

The crystals of *p*-azotoluene belong to the monoclinic prismatic class and space group C^5_{2h} with two molecules per unit cell. The relative intensities of X-ray reflections from some of the prism and the axial planes have been measured and the structure determined by the trial and error method. The orientations of the molecule in the cell are defined by the angles

$$\theta = 25°, \ \phi = 10°, \ \psi = 0°$$

where θ is the angle through which the molecule, initially placed with its plane parallel to the (010) face with the length along the *a* axis, is rotated about the *c* axis, ϕ the angle through which it is rotated about the *a* axis, and ψ the angle by which it is rotated about the *b* axis. The above results are supported by the magnetic anisotropy measurements which have also been made on the crystals.

30. The influence of nitrogen peroxide on the spontaneous ignition of mixture of *di*-ethyl ether with oxygen.

G. P. KANE *and* M. G. PANDIT, Bombay.

Previous investigation has shown that at temperatures between 200° and 400° under circumstances involving a two-stage spontaneous ignition of simple paraffin hydrocarbons such as propane, the effect of NO_2 addition is of a composite nature, consisting in a simultaneous inhibition of the reactions leading to cool flames and a promotion of the direct oxidation of the hydrocarbon. A similar result has been obtained with acetaldehyde, the inhibition of the cool flame reaction being the greatest observed so far.

This paper describes the results of experiments with *di*-ethyl ether-oxygen media with regard to the influence of NO_2 additions, on (1) the lower pressure limits of propagation of spontaneously ignited cool flame and true ignitions and (2) on the time lag prior to the initiation of cool flame and true ignitions.

It was found that NO_2 additions up to 6 per cent had no appreciable effect on the low pressure limits for cool flames, while at a constant pressure of the combustible mixture, the time lag generally increased continuously with NO_2 additions, indicating an inhibition of the reactions leading to cool flames.

For true ignitions, the low pressure limit decreased with an increase in the NO_2 content up to circa 3·5 per cent, while it increased steadily with greater NO_2 additions. At constant pressure of the combustible mixture, however, the time lag prior to ignition increased continuously with NO_2 additions.

The bearing of these results on the mechanism of combustion of hydrocarbons and allied fuels is described briefly.

31. Interaction of hydrogen and nitrous oxide under silent electrical discharge.

S. S. JOSHI *and* G. S. DESHMUKH, Benares.

Studies of this reaction which have been in progress for a considerable time in these laboratories have shown that the mechanism of the change is not only very much more complex when produced under the discharge, compared with the thermal and photochemical reactions (Hinshelwood, *Proc. Roy. Soc.*, 1924, A, **106**, 292–298), Melville (*Proc. Roy. Soc.*, 1933, A, **142**, 524–545), Dixon (*J. Amer. Chem. Soc.*, 1935, **57**, 818–821), Cassel and Cluckaub (*Z. physikal. Chem.*, B, 1932, **19**, 47–62) and MacDonald (*J. Amer. Chem. Soc.*, 1928, 1–14). While H_2O and N_2 are presumably the sole products in the thermal reaction, the discharge reaction yields besides undecomposed nitrous oxide, nitric oxide, nitrogen peroxide, ozone, water, hydrogen, nitrogen pentoxide and nitrogen trioxide in proportions, which depend not so much on the electrical factors such as the applied potential, the frequency and the magnitude of the secondary current, the energy dissipated in the reaction space, as the gas pressure, the mutual proportions of the two components and especially the stage of the decomposition produced at a given potential.

Results are simplest when hydrogen is present in a preponderating excess. This has been studied in considerable detail in the pressure range 170 to 463 mm. Hg at a fixed potential of 3,200 volts (r.m.s.). The pressure diminishes during the course of the reaction. Its rate is small during (*a*) the beginning; increases very appreciably during (*b*) the second stage; tends to be constant during (*c*) the last stage. The corresponding discharge current shows a rapid diminution during (*a*); it tends to be constant or rise during (*b*) and (*c*) with fluctuations towards the end. The duration of the reaction at a fixed applied potential increases from about 45 to 850 minutes as the initial pressure is varied between the values mentioned above.

Results of a series of experiments made with approximately equal proportions of nitrous oxide and hydrogen show, that during (*a*), both the pressure and current increase, and that this is slower greater the initial pressure; during the next stages (*b*) and (*c*), both pressure and current diminish with time. *After (c), however, instead of a steady state being reached the pressure rises, reaches a maximum and then diminishes to a minimum to rise once more, through a series of 'pressure reversals'* which persist for a long period (they were actually observed in one case for 1,200 minutes, the time corresponding to $a+b+c$ being about 150 minutes). It was remarkable to observe that the corresponding discharge current shows *synchronous 'reversals'*, the current being at the minimum when the pressure also was minimum and *vice versa.*

This is not a merely periodic fluctuation in the rate of the pressure change, as might come about by a like change in the applied potential but a *reversal in the sense or the direction* of the reaction, as shown by a periodic diminution and rise of pressure. Detailed results have been obtained for the influence of temperature in the range 7 to 60°C. on the occurrence of these *reversals.*

At high pressures the reaction was found to be uncontrollably fast after a brief initial stage; its duration is almost hyperbolically related with the magnitude of the initial pressure.

At still higher proportions of nitrous oxide practically all the above phenomena are observable with the rather significant difference that the *pressure reversal* do not continue almost indefinitely as in previous cases, but that their amplitudes diminish as in a succession of damped oscillations. This remark applies fully to the corresponding synchronous variations of the current.

32. Interaction of phosphorus with nitrous-oxide under the electrical discharge.

S. S. JOSHI *and* Y. D. KANE, Benares.

This reaction has been studied in electrical discharges due to alternating potentials which were varied in the range 2,000 to 9,000 volts (r.m.s.) at a frequency of 50 and 500 cycles per second of the A.C. supply. The annular space of the Siemens' tube was coated with a film of phosphorus. The gas pressure was varied in the range 110 to 150 mm. Hg. Under exposure to discharge the pressure diminishes first rapidly and then slowly, practically to zero, at the end of the reaction. The time variation of the current shows a remarkably synchronous parallelism with the above-mentioned sections on the pressure–time curves. The current rises rapidly during the first phase and slowly subsequently; during this phase the pressure diminution is also slow. This is by far the longest stage and almost completely accounts for the entire duration of the reaction; the last stage which is very brief involving the loss of the residual 3-4 mm. of the gas, produces a very sudden and enormous diminution (about 4–6 fold) in the discharge current.

This pressure diminution has been traced to the absorption by phosphorus of both oxygen and nitrogen produced by the decomposition of N_2O. Interesting results have been obtained on the absorption, under electrical discharge of nitrogen at moderate pressures. Production of a nitride of phosphorus has been definitely established in all these experiments.

It was found that the threshold potential for the decomposition of nitrous oxide under electrical discharge was defined much less sharply when produced in contact with phosphorus film than in the corresponding homogeneous change. Data of further experiments for this and similar discharge reactions studied in these laboratories show that the above result is general.

Nitric oxide, nitrogen and undecomposed nitrous oxide have been observed to be amongst the initial products of decomposition. Nitrogen and oxygen occur after about 3 per cent of the total time for the reaction. A theory has been proposed for the mechanism of the change under the discharge.

33. The interaction of sulphur and nitrogen under electrical discharge.

S. S. JOSHI *and* SADANAND SIRSIKAR, Benares.

Sulphur deposited (as a thin film from carbon disulphide solutions) on the inside walls of the annular space of a Siemens' ozonizer was exposed to electrical discharges at low pressures of nitrogen, varied in the range, 25 to 150 mm. Hg at 50 cycles per second and about 11,000 volts (r.m.s.). A progressive diminution of the pressure (the rate being high during the initial stages) was produced. At high initial pressures the pressure was reduced almost to zero at the minimum, which took about 8 hours of continuous exposure to the discharge. Curiously enough, it was found that on a continuation of the discharge after the attainment of this minimum, the gas pressure increased slowly but sensibly. It took, for instance, about 5 hours of exposure *after the minimum* to reproduce about

0·75 per cent of the gas pressure, which was introduced at the commencement of the reaction. It was very interesting to observe that the corresponding discharge current diminished to a minimum and showed a subsequent rise fairly concurrently with the above pressure variations. The rate of the reaction at a given applied potential and frequency, as judged by the significant pressure change, on both sides of the minima, becomes greater the smaller the initial gas pressure; the corresponding recovery to the initial pressure is also more complete.

The presence of sulphur nitride produced under discharge under the above conditions has been definitely established and accounts for a substantial part of the pressure reduction. Presumably, a portion of this sulphur nitride decomposes during the stage after the minimum on the pressure–time and current–time curve, which would explain the observed pressure reversal.

The spectral appearance of the glow was markedly different before and after the 'reversal'. The rise of the current and of the pressure after it, is rapid in the beginning; they then gradually slow down into a stationary state. Once this last stage is attained (unlike that during the pre-reversal stage) further continuation of the discharge even for large periods of time has no influence on the constancy of the pressure and the discharge current.

34. An 'ageing' effect in bromine vapour under electrical discharge in Siemens' tubes.

S. S. Joshi *and* Sadanand Sirsikar, Benares.

It has been found that similar to chlorine (*cf.*, Joshi and Narasimhan, *Proc. Indian Sci. Cong.*, 1940, Part III, p. 24), the discharge current produced in bromine vapour at a fixed frequency shows a marked diminution after the application of the secondary potential to the vessel. The discharge was produced in the annular space of a glass ozonizer of the Siemens type.

The diminution of the current was very rapid soon after the initiation of the discharge; it then slowed down into a steady state, when the current remained constant. If, however, the discharge was discontinued at this stage and re-started at the same applied potential as before the secondary current was not fully restored to the original value. The restoration was completed the greater the time interval between the discontinuation and reproduction of the discharge. In one series of experiments at 8,000 volts about 4·5 hours of interval had to be allowed after the switching off of the secondary potential, when on its re-application the original current was obtained. These hysteresis effects were found to be a function of, and decreased with the applied potential. The initial diminution of the current also was greater the greater the applied potential, other factors remaining unchanged. The above '*ageing*' effect increased on the exposure of the system even to stray radiation at all the stages of the time—current curves.

35. Behaviour of chlorine subjected to electric discharge and irradiation.

S. S. Joshi *and* K. Kuppuswamy, Benares.

It has been observed that irradiation introduces very appreciable differences in the electrical properties of chlorine subjected to discharges due to alternating fields. The gas was contained in the annular space of a Siemens type ozonizer made of glass; NaCl solution served as electrodes. The arrangement admitted therefore of exposing the gas to an external source of radiation before or after the initiation of ionization by applying the necessary potential to the ozonizer.

In the range of 55–500 mm. Hg the minimum threshold potential (*cf.*, Joshi. *Curr. Sci.*, 1939, **8**, 548) was *greater* under irradiation than in the dark, for a given value of the gas pressure and frequency of the A.C. supply. As is to be anticipated (*loc. cit.*), the discharge current *in the dark* produced at a given gas pressure, applied potential and frequency *diminished* appreciably as soon as the system was exposed to light. It is believed that this suppression θ of the secondary current observed for the first time in these laboratories (*cf.*, Joshi and Narasimhan, *Proc. Indian Sci. Congress*, 1940, Part III, p. 40) represents a hitherto unrecognized phenomenon in the already vast and rapidly accumulating data on the discharge phenomena in the gases.

It has been found that θ *observed for a constant light intensity* at a given gas pressure (varied in the range mentioned above) increases by increasing the applied potential (varied from 3,000 to 7,000 volts) at a constant frequency and temperature; it also increases by reducing the temperature studied in the range 7°–75°C., the pressure, potential and frequency being kept constant. θ is also greater higher the frequency of the A.C. supply varied from 50 to 500 cycles per second, other factors mentioned above remaining unaltered.

Data are given for the influence on θ of different proportions of foreign gases.

36. Studies in the electrolysis of aqueous cobalt sulphate. Part I. Electro-deposition of cobalt on iron.

S. S. JOSHI, D. N. SOLANKI, *and* B. N. DUTT, Benares.

A review of the literature shows that very little work has been done on cobalt deposition, though the sister metal nickel has, thoroughly, been investigated. A study has, therefore, been made in these laboratories, to investigate the optimum conditions for smooth, lustrous, adhesive and satisfactory deposits. The influence, on the nature and quality of the deposit was examined microscopically, of the following factors: (i) electrolyte concentration, (ii) interelectrode distance, (iii) duration of electrolysis, (iv) C.D., (v) temperature, (vi) bubbling air through the electrolyte, and (vii) addition agents.

In the experiments, under (i), the concentration of cobalt-sulphate used for the bath solution, was varied, in the range $1{\cdot}5M$-$M/16$. Results show that satisfactory deposits at a particular C.D. can be obtained only from $\frac{M}{2}$ solution as stronger and too dilute solutions are found to give less satisfactory deposits, former due to too high a metal-ion-content and the latter, to a local impoverishment of the metal or metal-ion-content or to lack of crystal centres round the cathode. Our results show that satisfactory deposits are obtained only with duration, 5 to 20 minutes, after which the deposit shows distinct tendency to peel off. Our data, under (iv), show that with the rise in C.D. the quality of the deposit improves, the optimum value being 90 to 120 amps. per sq. ft. Further increase of C.D. brings about a burnt deposit; and very high C.D. makes the deposit rough, loose and powdery. At a very low C.D. like 10 or 5 amps. per sq. ft. there is hardly any deposit probably due to whole of the current being utilized in discharging undesirable hydrogen. Our results, under (v), indicate that uniformly shining and lustrous deposits are obtained at low temperature (10°C.); with the rise of temperature the crystal size goes on increasing till at 70°C. the deposit becomes hopelessly black.

Experiments, under (vii), showed that the addition of H_2SO_4, H_2O_2, boric acid, Na_2SO_4, glycerine, glucose, etc., had a good and favourable effect on the nature of the deposit; whereas the addition of $SnCl_2$, $Al_2(SO_4)_3 \cdot 18H_2O$, $CdSO_4$, gelatine, aniline sulphate, etc., proved to be

detrimental. Addition of 2% H_2O_2 to the bath gave excellent deposit possibly due to hydrogen evolution being arrested.

37. Studies in the electrolysis of aqueous cobalt sulphate. Part II. Anodic oxidation of cobaltous to cobaltic sulphate and its confirmation from spectroscopic observations.

S. S. JOSHI, D. N. SOLANKI, *and* B. N. DUTT, Benares.

During the preliminary experiments on deposition of cobalt by electrolysis of cobalt sulphate, a serious difficulty arose due to precipitation of a brown-black product with the progress of electrolysis. The product was, after analysis, found to be hydroxide of cobalt acting as peroxide. To avoid this precipitate formation several anodes of the insoluble type were used, in absence of the pure cobalt metal. Smooth Pt, Pt coated with black platinum, Au, Pb, and graphite were tried as anode materials. In all the cases there was precipitation of the brown peroxide, either in floculent mass or in the form of thin film over the anode. With black Pt anode, the precipitation occurred immediately, hardly within a minute or two after electrolysis. Anodes of the soluble type like Ag, Sb, Bi, Al, etc., were also tried and were found to show the similar anodic phenomenon, though to a very negligible extent due to main anode reaction being the dissolution of the metal used.

In quantitative measurements of the deposition of cobalt by electrolysis of cobalt sulphate by using Pb anode (iron cathode) another curious behaviour was noted. No two consecutive readings for cathode efficiency for metal deposition agreed though the measurements were made under constant conditions of temperature, C.D., etc. The cathode efficiency continuously goes on falling. This difficulty, i.e. lack of agreement between consecutive quantitative observations could not be completely overcome by varying the conditions like the bath composition, temperature, C.D., etc., though the agreement was satisfactory, with the bath, containing cobalt sulphate, and buffered with NaH_2PO_4 and H_3PO_4, at very high temperature (70°C.). The continuous fall or diminution of the cathode efficiency under normal conditions may be attributed to a valency change of cobalt from divalent to trivalent by anodic oxidation with the progress of electrolysis. That there is a valency change during the electrolysis of cobalt sulphate has been further confirmed from spectroscopic measurements by taking micro-photographs of the absorption spectra for cobalt sulphate solution, before and after electrolysis, and also for cobaltic sulphate solution prepared by electrolytic method.

38. Electro-deposition of cadmium on iron.

S. S. JOSHI, D. N. SOLANKI, *and* B. G. JOSHI, Benares.

A review of the literature shows that much of the work on cadmium deposition is restricted to the use of double cyanide solutions, which are, however, unstable and too often apt to undergo decomposition and thus offer many practical difficulties in maintaining the satisfactory control of the bath. Experiments carried out in these laboratories, under varying conditions of (i) electrolyte concentration, (ii) inter-electrode distance, (iii) C.D., (iv) time duration, and (v) temperature, showed that no satisfactory smooth and adherent deposits could be obtained from cadmium sulphate bath. At constant values of concentration, C.D., temperature, etc., the deposit, which was initially bright and adhesive, became, as the time elapsed, powdery, non-adhesive and black due to the increased alkalinity of the bath with the progress of the electrolysis, and subsequent inclusion of the basic hydroxides in the cathode deposit. Kurda's (*Z. physik. Chem.*, 1936, **175**, 377–382) findings lead to similar

conclusions. Our results show that the addition of free H_2SO_4 to the bath solution considerably improved the nature and quality of the deposit, as examined microscopically. The concentration of H_2SO_4 was varied in the range $N/50$–$N/4$; most satisfactory deposits were obtained in the presence of $N/50$ H_2SO_4. Increased concentration of the acid, however, besides lowering the cathode efficiency to a considerable extent due to excessive hydrogen evolution, gave cracked and pitted deposits with deep crevices. Our results with the addition of Na_2SO_4 (1 to 10%) to the bath (4% cadmium + $N/50$ H_2SO_4) show that both quality and quantity of the deposit get very much improved with increased amount of the added material, up to 5% and then remain almost unaffected with 10%. The favourable results can be attributed to sodium sulphate acting, either, as a conducting salt, or, as a bath stabilizer by its buffer-action.

The influence of C.D. and temperature, on the nature and magnitude of the deposit from the bath (4% cadmium + $N/50$ H_2SO_4 + 5% Na_2SO_4), has been studied in detail. Our data show that with the increase in C.D. the grain-size becomes finer and finer up to a particular limit (5 amps./sq. ft.), however, the deposit shows tendency towards tree-formation or burning. The cathode efficiency gradually increases with C.D. but the increase is very small which shows that C.D. has no marked influence on cathode efficiency of cadmium deposition, possibly due to absence of hydrogen evolution, under the operating conditions of the bath. Wernick (*Trans. Electrochem. Soc.*, 1932, **62**, 75–86) and Watanabe and Tsuchimoto (*J. Min. Met.*, Japan, 1929, **7**, 3–10, 34–40) obtained similar results. Our data show that both quality and quantity of the deposit at constant C.D. improve by increasing the temperature up to a certain extent (45°C.) and deteriorate at higher temperatures (80°C.).

Under the optimum conditions, the effect on quality and quantity of the deposit was studied by adding, to the bath, various inorganic and organic substances. $Al_2(SO_4)_3 \cdot 18H_2O$, $NiSO_4 \cdot 7H_2O$, H_2O_2, $ZnSO_4 \cdot 7H_2O$, $HgCl_2$, Cr_2O_3, $SnCl_2$, SnO, SnO_2 and traces of $SnCl_4$, $SbCl_3$ and $BiCl_3$ were tried. A trace of $SnCl_2$ gave most satisfactory deposits possibly due to its hydrolysis and subsequent inclusion in the deposit. Good deposits were also obtained in presence of nickel sulphate. Other substances either showed no much improvement ($Al_2(SO_4)_3 \cdot 18H_2O$, $ZnSO_4 \cdot 7H_2O$, etc.) or gave hopelessly bad and spongy deposits (Cr_2O_3, $HgCl_2$, etc.). Addition of dextrin or gelatin improved the nature of the deposit; while pyridine, carbon disulphide, sucrose and glycerine gave unsatisfactory deposits.

39. A study of some physico-chemical factors in the electro-deposition of nickel.

S. S. JOSHI, D. N. SOLANKI, *and* DAMRI SINGH, Benares.

A review of the literature shows that though much work has been done on electro-deposition of nickel, the information available regarding the quantitative deposition of the metal under various conditions, is very meagre. A detailed and exhaustive study, has, therefore, been made, to investigate the optimum conditions for smooth, adherent and satisfactory deposit of nickel over iron as the base metal, from a bath containing nickel sulphate, nickel chloride and boric acid, at various values of electrolyte concentration, inter-electrode distance, duration of electrolysis, temperature, C.D., and pH. Under constant optimum conditions of electrolyte concentration, electrode distance, duration, and pH (5·6) the influence of the following factors on cathode efficiency for nickel-deposition has also been studied in detail.

(i) Temperature, (ii) C.D., (iii) addition agents, organic and inorganic, in small quantities, (iv) addition of non-electrolytes, in large quantities, (v) nature of the cathode material, (vi) superimposing A.C. on C.D., causing deposition, and (vii) bubbling air, under pressure, through the

electrolyte during the electrolysis. Our data, under (i), show that the quality of the deposit improves by increasing the temperature up to a certain extent (about 45°C.) and deteriorates at higher temperatures; though it slightly diminishes at very high temperature, especially for high C.D. It is interesting to note that the effect of temperature in raising the cathode efficiency is more marked at low C.D. than at high C.D. Our results, under (ii), show that at too low a C.D., either, there will be no deposit, or, it will be dull and unsatisfactory, the cathode efficiency being too low due to excessive hydrogen evolution. With increase in C.D., however, the quality and quantity of the deposit improve, up to a particular limit due to gradual diminution in hydrogen evolution, and then deteriorate at higher C.D., which gives powdery, burnt and spongy deposits due to rapid depletion of the metal ion content round the cathode.

Amongst the addition agents tried H_2O_2 and $Al_2(SO_4)_3.18H_2O$ proved to give most satisfactory and fine-grained deposits, the former by arresting the hydrogen evolution, evidenced by high cathode efficiency and the latter due to its hydrolysis and subsequent inclusion in the cathode deposit. Addition of $CdCl_2$ and dextrin in small quantities proved beneficial; while addition of $HgCl_2$, $SnCl_2$, glue, pyridine, CS_2, and acetone proved detrimental. Chromic acid (CrO_3') was found to be highly detrimental even in minute traces, only facilitated free evolution of hydrogen.

Our results with the additions of non-electrolytes—ethyl alcohol, glycerine, methyl alcohol, sucrose and mannitol—in large quantities show that the cathode efficiency increases steadily with the progressive addition of the non-electrolyte in all cases, till it approaches a limiting value; it remains practically constant being unaffected with further addition, in the case of C_2H_5OH and glycerine, but is depressed in the case of mannitol and sucrose. The conductivity, viscosity and density measurements of these solutions were also made.

40. Variation of transport number of silver ion in water-methyl alcohol solutions.

HARIRAO J. ARNIKAR, Benares.

Contrary views are held regarding the influence of the medium on the transport number of silver ion. Carrara (*Gazetta*. 1903, **33**, (i), 241) believes that no complex is formed in the medium, while others notably Krummreich (*Zeit. Elektrochem.*, 1916, **22**, 446) find it necessary to assume the formation of an alcohol-water complex to account for the maximum in the transport number curve. Data recorded in the present paper for the transport number of silver ion in $M/20$ silver nitrate solutions in water-methyl alcohol medium at constant temperature, agree with those of Krummreich for water-ethyl alcohol media. Corresponding variations in the viscosity, surface tension, electrical conductivity, and coefficient of apparant volume expansion of medium also are studied and enough evidence is to be found in these data for the formation of a complex at about 35 per cent methyl alcohol by weight and this is in complete agreement with the views of Getman, Dunstan and Trauba ('Viscosity' (Monogram on Inorganic and Physical Chemistry series), 1914) who from the viscosity and other data have shown that complexes of the type $CH_3OH . 3H_2O$, and $C_2H_5OH . 3H_2O$ are formed.

41. An extrapolation method for determining single electrode potentials.

SUBODH KUMAR MAJUMDAR *and* DURGADAS CHAKRABORTTY, Calcutta.

Measurement of single electrode potentials, as is well known, is a matter of great difficulty. Various methods, such as those depending on

the use of the Dropping Electrode, Capillary Electrometer, etc., have been proposed. A null electrode method was proposed by Benewitz and Schulz (*Z. f. physikalische Chemie*, 1926, **124**, 115), which involves destruction of the double layer on one of two similar electrodes dipped in the same solution. The metal ion concentration of the solution is altered and the point is noted at which no current flows through the system. At this point the potential difference between solution and electrode is assumed to be zero and this electrode can be subsequently used as null electrode. A modification of this method has been attempted. The standard value of normal electrode potential of silver (as against normal hydrogen electrode) is given by Lewis ("Thermodynamics and Free Energy of Chemical Substances." 1923) as + 0·7995 volt, from which the silver ion concentration, at which the silver electrode will behave as null electrode, comes out to be $8{\cdot}71 \times 10^{-14}$. Reversible silver electrodes, prepared by various methods, were dipped in silver nitrate solutions of various concentrations and the E.M.F. was measured at 35°C., with N-KCl- and saturated KCl-calomel electrodes, using NH_4NO_3 bridge. The silver ion concentration was varied by (i) dilution, (ii) precipitation of silver by standard KI solution, and (iii) removal of silver ion by adding standard ammonia solution, and the E.M.F. of the chain measured. The value of the E.M.F. thus found was plotted against log [Ag^+] and the value of E.M.F. extrapolated for −13·06. This obviously corresponded to the single electrode potential of the calomel electrode, as the silver electrode at this stage behaved like a null electrode. A series of solutions of different concentrations of silver nitrate with the same electrode was studied and the curves for the same electrode showed the same inclination, excepting for ammonia and at very low concentrations of silver ion ($5 \times 10^{-3} N$). Evidently the discrepancy in the former case is due to the formation of ammonia complexes of uncertain composition and in the latter due to the fact that the Ag-electrode, like many other metal electrodes, is not reversible at very low silver ion concentrations. The results obtained by the other two methods show quite satisfactory concordance, with the results previously obtained, as will be seen from the following:—

N-KCl calomel .. + 0·279 volt.
+ 0·2786 (Glasstone).
+ 0·2824 (Clarke).

It should be added, however, that the method does not propose to give absolute values but only values relative to the normal hydrogen electrode.

42. A push pull electrometer valve potentiometer.

C. T. Abichandani *and* S. K. K. Jatkar, Bangalore.

A Push Pull Electrometer Valve Potentiometer consisting of two Osram Electrometer Valves in push pull followed by two P_2 valves also in push pull, which gave no drift in a mirror galvanometer has been described in this paper.

43. Dissociation constants of isomeric halogeno-phenols.

C. T. Abichandani *and* S. K. K. Jatkar, Bangalore.

The dissociation constants of *o*-, *m*- and *p*- halogenophenols from the electro-motive forces of the cells without liquid junction, using the push pull electrometer valve potentiometer, have been measured. The hydrogen electrode was replaced by a glass electrode, as the former was easily poisoned. A linear relationship has been shown to exist between the field intensity at the carbon atom and the logarithm of dissociation constant. The effect of the dielectric constant of the medium on the dissociation

constants has been determined. The infra-red spectra of phenols has been discussed in relationship to the structure of the compounds.

44. Dispersion of dielectric constants of binary mixtures.

(MISS) NAGAMANI SHAMA RAO *and* S. K. K. JATKAR, Bangalore.

The dielectric constants of the system benzene-carbon tetrachloride in liquid state have been measured over a frequency range of 23 to 10,000 k.c., using piezoelectric quartz oscillators. The dispersion is not appreciable over this range, and the molar polarization P_{12} and polarization P_2 shows a sharp minima at the composition where the cryoscopic methods indicate one to one complex and the selective adsorption by silica gel, is zero. A maximum is shown in the dielectric constant curve as well as in the selective adsorption curve by norit and silica gel when the composition of the mixture corresponds to $CCl_4 . 4C_6H_6$.

45. Dipole moments and molecular structure. Part I. Dipole moments of ethyl esters of phenyl substituted acetic, malonic and glutanic acids.

N. L. PHALNIKAR, B. V. BHIDE, *and* K. S. NARGUND, Poona.

Dipole moments of the following esters have been determined in benzene solution at 30°C. at 100 meters wavelength.

1. Ethyl phenyl acetate (1·824).
2. Ethyl phenyl methyl acetate (1·82).
3. Ethyl diphenyl acetate (1·76).
4. Diethyl phenyl malonate (2·54).
5. Diethyl phenyl methyl malonate (2·52).
6. Diethyl diphenyl malonate (4·43).
7. Diethyl phenyl glutarate (2·51).
8. Diethyl diphenyl glutarate (2·43).

The numbers in the brackets are the dipole moments in Debye units. The study of the moments of ethyl esters of phenyl substituted acetic, malonic and glutaric acids have shown that the effect of the phenyl group on the moments of these acetates and glutarates is very small, but there is a definite inductive effect of the phenyl group on the moments of phenyl substituted malonates.

46. Dipole moments and molecular structure. Part II. Dipole moments of ethyl esters of alkyl substituted malonic acids.

N. L. PHALNIKAR, B. V. BHIDE, *and* K. S. NARGUND, Poona.

Dipole moments of the following esters have been determined in benzene solution at 30°C. at 100 meters wavelength.

1. Diethyl malonate (2·54).
2. Diethyl dimethyl malonate (2·32).
3. Diethyl diethyl malonate (2·10).
4. Diethyl dipropyl malonate (2·15).
5. Diethyl mono-isopropyl malonate (2·40).

An equation has been derived to calculate the moments of compounds of the type of diethyl esters of substituted malonic acids. Using this equation the moments of diethyl esters of substituted malonic acids have been calculated and the observed values are shown to be in accordance with the valency deflexion hypothesis.

Earlier values of dipole moments of cycle 1 : 1 dicarboxylates determined by Farmer and Wallis (*J.C.S.*, 1933, 1307) have been recalculated and shown to be in accordance with the valency deflexion hypothesis.

47. Charge and stability of colloids. Part III. Potentiometric titration of ferric hydroxide sol.

B. P. YADAVA *and* A. C. CHATTERJI, Lucknow.

In the previous two papers of this series the relation between charge and the stabilizing effect produced by the addition of minute quantities of H_2S, HCl and non-electrolytes like methyl alcohol, ethyl alcohol agar-agar, etc., were studied.

In this paper the changes produced in the ferric hydroxide sol prepared from ferric chloride by the addition of ammonia have been followed potentiometrically step by step when various coagulating electrolytes are added gradually in increasing quantities.

The method followed is essentially one which has been developed by Rabinowitsch and Weiser with modifications introduced to reduce the liquid junction potential to a minimum. The results obtained indicate that the quantity of chloride set free by the added electrolyte is sometimes greater than the electrolyte added. Weiser's opinion that this is due to faulty experimental procedure and observation is not true.

It has been found that if the sol is impure, the quantity of chloride liberated is greater than the equivalent amount of the coagulating electrolyte. With progress of dialysis the same sol sets free lesser quantities of chloride than the amount of electrolyte added.

48. Charge and stability of colloids. Part IV. Potentiometric titration of aluminium hydroxide sol.

B. P. YADAVA, Lucknow.

In this paper potentiometric titrations of aluminium hydroxide sol prepared from aluminium chloride and ammonia have been studied. It has been found that when the impure sol is titrated with potassium sulphate, the quantity of chlorine liberated is greater than the amount of sulphate added. But when the same sol is purified by dialysis the quantity of chlorine set free by the addition of potassium sulphate is considerably less than the sulphate added.

49. Base-exchange of mercuric ions adsorbed on wool.

G. T. GURSAHANI *and* C. S. NARWANI Karachi.

The base-exchange experiments have been performed with various chlorides and sulphates having monovalent and divalent cations on sheep wool treated with various solution of $HgCl_2$ in 0·025*N* HCl for 24 hours, in an air thermostat at 35°C. and thus the adsorption of Hg ions has been established as shown by the following results:—

(1) Total quantity of Hg taken by one gm. of wool goes on increasing with the initial concentration of $HgCl_2$ first rapidly up to 0·15*M* and then slowly and regularly; there is a diversion in the curve at equilibrium concentration corresponding to 0·1*M* initial concentration. There is a slight increase in the total quantity of Hg taken up with the increase in time. (2) The quantity of Hg ions exchanged by Na ions goes on increasing with the equilibrium concentration of $HgCl_2$ following nearly a parabolic curve. (3) The quantity of Hg exchanged by various monovalent cations follows the order $K > NH_4 > Na$, that by divalent cations $Ca > Ba > Mg$, in case of chlorides as well as sulphates, it being more by the latter. (4) In presence of NaCl, the quantity of Hg taken up by one

gm. of wool goes on decreasing with the increase in concentration of NaCl. On subtracting the exchanged, i.e. the absorbed quantity of Hg from the total quantity taken up by one gm. of wool, the quantity combined is obtained. If the quantity of Hg reacted with one gm. of wool is plotted against equilibrium concentration there is a diversion in the curve at the equilibrium concentration corresponding to $0 \cdot 1M$ initial concentration, showing two types of reactions.

50. Alkaline electrometric titrations of gelatin in presence of sugars.

RAM D. ADVANI *and* C. S. NARWANI, Karachi.

Addition of 0.5–3.0 m.mols of aldo- and keto-sugars per 100 c.c. of gelatin-water sol gives a definite decrease in pH value varying with the nature of the sugar in the following order:—

Mannose > Glucose > *l*-Arabinose = Xylose > Galactose > Fructose > Maltose > Lactose.

On adding non-reducing sugars there is practically no change in pH value.

The gelatin sols, mixed with various quantities of different sugars, were titrated electrometrically (hydrogen electrode) with standard sodium hydroxide solution, to verify the increase in acidity on condensation of aldo- and keto-groups with NH_2 groups. Plots of pH against the quantities of sodium hydroxide added, were prototype and did not overlap each other. With increasing concentrations of every sugar, the quantity of alkali required, for reaching the neutral point (pH = 7) goes on increasing gradually, and the increase with the similar concentration of different sugars was different and followed the order—

l-Arabinose > Mannose > Galactose = Fructose > Xylose > Maltose > Lactose.

It is concluded that the condensation power of each sugar varies with pH of the mixture.

51. Studies on nucleic acid. Part I. Variation of properties with concentration.

S. N. MUKHERJEE, Calcutta.

Specific conductivity, hydrogen ion activity, cataphoretic velocity and total acidities as obtained from potentiometric titrations have been studied at different concentrations of the nucleic acid (from yeast) sol. Variations of specific conductivity with concentration as well as of equivalent conductivity with square root of concentration as calculated therefrom do not indicate any aggregate formation at the concentrations studied by us (up to 3×10^{-3} equiv. per litre). Changes in cataphoretic velocities with concentration, however, were indicative of the formation of aggregates but ultramicroscopic determination of the size of the particles did not confirm this. The total acidity was, however, found to be proportional to the concentration.

52. Studies on nucleic acid. Part II. Potentiometric and conductometric study of the reaction with different bases.

S. N. MUKHERJEE, Calcutta.

Potentiometric titration curves of the same specimen of nucleic acid sol with different bases showed different total acidities at the same pH. The order of acidity was found to vary as $Ba(OH)_2 > Ca(OH)_2 > NaOH > KOH > NH_4OH$. Conductometric titration curves confirm these observations qualitatively but such curves with $Ba(OH)_2$ and $Ca(OH)_2$ are

extremely complex having in fact as much as four inflexion points and peculiar shapes. The first inflexion point with KOH agreed with the free acidity of the sol as obtained from pH measurements. Difference in total acidity with different bases, however, disappears in the case of the ultrafiltrate which obviously indicates that the observed effect is due to the presence of colloidal particles in the system.

53. Electrochemical properties of arabic acid sol. Part I. Potentiometric and conductometric studies on the reaction with bases.

S. N. MUKHERJEE, Calcutta.

In arabic acid sol different bases showed different total acidities both in potentiometric and conductometric measurements. The order of total acidity indicated by the bases run as follows—Ca > Ba > K > Na (*cf.*, lyotropic series). This difference persisted to a certain extent even when the sol was electrodialyzed. Titration curves indicated its monobasic nature. The first inflexion point in the conductometric curves tallied with H-ion activity of the sol while the second inflexion point which showed variation with different bases compared favourably with those obtained from potentiometric titration curves. Total acidity varied linearly with concentration as observed with NaOH. Dissociation constants as calculated from both types of measurements tallied with each other and they were found to increase with rise in concentration.

54. Effect of non-electrolytes on the specific conductivity and pH of silicic acid sols.*

B. CHATTERJEE, Calcutta.

When increasing amounts of glucose (G.R.) were added to electrodialyzed silicic acid sols the specific conductivity at first increased and then decreased while the pH initially diminished then slightly increased tending to a constant value. The specific conductivity continuously increased from the beginning when longer time was allowed for interaction. The specific conductivity of the ultrafiltrates of the mixtures showed similar results. Some sort of interaction appears to take place between silicic acid sol and the added glucose.

55. Variations in the pH, specific conductivity, total neutralizable acid and forms of titration curves of colloidal solutions of hydrogen clays and hydrogen bentonites on the addition of non-electrolytes.*

R. P. MITRA *and* K. C. GHOSH, Calcutta.

When alcohol (G.R. quality) is gradually added to a carefully purified hydrogen clay or hydrogen bentonite sol (sp. cond.—*Ca* 3 [illegible] mho.; pH—*Ca* 5·0; colloid content—2*g*/l) its specific conductivity at first rapidly increases, reaches a maximum at a concentration of about 0·05 per cent of the added alcohol and then decreases. The decrease is first rapid and then slow, the conductivity ultimately tending to become constant. Corresponding to the variations in the sp. conductivity, the pH at first rapidly decreases, passes through a minumum and then rises and approaches a limiting value. The ultrafiltrates also show similar but much less prominent maxima and minima. The pH and sp. conductivity of the sol change with time indicating a slow reaction which is, however, not an ordinary dissolution process as in that case a continuous variation

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* The work has been carried out under a scheme of research financed by the Imperial Council of Agricultural Research, India.

in the pH and sp. conductivity instead of the maximum and minimum would be observed. A hydrogen clay which had been repeatedly washed with 25% alcohol also showed such discontinuous variations. They were not observed with solutions of HCl having nearly the same pH and sp. conductivity as the sol. The total acid (at the inflexion point of the potentiometric titration curve with a base) of the sol estimated in the presence of increasing amounts of alcohol also passes through a maximum. The ultrafiltrate, however, contains little or no titratable acid which further shows that practically no acid is brought into solution by the alcohol. The titration curve of the sol—alcohol mixture has a stronger acid character than that of the sol itself.

56. The electrochemical properties of synthetic mixtures of silicic acid and aluminium hydroxide sols.*

B. CHATTERJEE, Calcutta.

Synthetic mixture of silica and alumina having $SiO_2 : Al_2O_3$ ratios (molar) of 2 : 1, 1 : 1 and 1 : 2 were prepared from electrodialyzed silicic acid and aluminium hydroxide sols. The mixtures were all electro-positive. The pH and specific conductivity of the mixtures change with time. The forms of the potentiometric titration curves of the mixtures with NaOH have different forms from those of either silicic acid or aluminium hydroxide sols. The titration curve of the mixture having ratio 2 : 1 shows two inflexion points (at pH 7·0 and 4·5) and that of ratio 1 : 1 only one inflexion point at pH 7·2. The mixture having ratio 1 : 2, however, shows no inflexion point in its titration curve. The total acidity calculated at pH 7·0 from the titration curves increases with an increase in the silica content of the mixtures.

57. Studies on the 'zonal effect' in electrolytic and mutual coagulation of colloids in the slow region by transparency determinations.

S. S. JOSHI *and* C. S. RAMAKRISHNAN, Benares.

The present work was undertaken with a view to extend the findings of Joshi and co-workers (*J. Indian Chem. Soc.*, 1936, **13**, 311–314; *ibid.*, pp. 439–447; *ibid.*, 1937, **14**, 103–108; *ibid.*, pp. 388–395; *Current Science*, 1936, **4**, 870) that increase in opacity or which is the same as decrease in transparency cannot be regarded, in general, as a measure of the corresponding degree of coagulation, and that the progress of the latter especially in the *slow region* is not a time continuous change as is contemplated in Smoluchowski's classical theory for the kinetics of coagulation (*Z. physik. Chem.*, 1917, **92**, 129). Two series of transparency determinations have been carried out in the present investigation. In the first, differently diluted sols of negatively charged manganese dioxide were coagulated in the presence of variously concentrated aqueous solutions of potassium chloride, barium chloride, propionic, butyric and succinic acids. The transparency time curves for all these coagulations showed the 'zonal effect', which became more pronounced the slower the coagulation, both in the number and the duration of each of the zones. Essentially similar results were obtained when the above coagulations were produced in the presence of sensitizing and protecting agents, and in the behaviour of positively charged ferric hydroxide mixed with differently concentrated solutions of chloride, sulphate and phosphate of potassium.

The discontinuities or the 'zonal effect' also appeared markedly conspicuous in the transparency–time curves for the numerous mutual

* The work has been carried out under a scheme of research financed by the Imperial Council of Agricultural Research, India.

coagulations between colloids, manganese dioxide, the prussian blue, cadmium sulphide and vanadium pentoxide which were negatively charged and the positive ferric hydroxide and aluminium hydroxide.

58. Opacity changes in the gel-forming mixtures during setting.

MATA PRASAD *and* V. S. GOGATE, Bombay.

An apparatus has been devised to measure the changes in opacity in which the fluctuations in the main current have been obviated by using a Barreter's filament valve. Compensated photo-cells were used in the apparatus and these were supplied by constant voltage by means of a neon stabilizer introduced in the circuit. This apparatus was used to measure the changes in opacity during the course of gelation of (1) stannic arsenate, (2) silicic acid, and (3) thorium molybdate gels. Effects of the addition hydrochloric acid and some non-electrolytes on the opacity changes have also been examined. The time-opacity curves obtained in the first two cases are 'S' shaped while those in the third case are hyperbolic.

59. Antinormal variation of opacity in coagulations due to mercurous sulphate.

V S. RAGHAVAN, Benares.

The present work arose out of the observation by Joshi and co-workers (*J. Indian Chem. Soc.*, 1936, **13**, 439; *ibid.*, 1937, **14**, 103; *ibid.*, pp. 157–171; also, *ibid.*, pp. 323-343; *Curr. Sci.*, 1936, **4**, 870) of the abnormality of effects when mercuric chloride was used as a coagulant. Purushottam has reported that aqueous mercurous sulphate produced abnormal changes in the transparency of colloid manganese dioxide (*Koll. Zeit.*, 1938, **85**, (i), 32; *ibid.*, 1939, **86**, (3), 361). The present paper gives data for the changes of opacity produced in colloid arsenious sulphide, cadmium sulphide, ferric hydroxide and mercuric sulphide mixed with equal volumes of differently concentrated solutions of mercurous sulphate. These results further confirm the notion that a change in opacity cannot be adopted as a measure of the corresponding degree of coagulation produced. Indeed in the present series of experiments it was found that in a number of coagulations, (each of which was followed till the setting in of flocculation, i.e. the appearance of optical heterogeneities due to discrete particles of the coagula), the system showed an overall *diminution*. It was observed, however, that whether the change of opacity was normal or otherwise, its time variation, in general was markedly discontinuous or '*zonal*'.

60. Variation of the viscosity of colloids subjected to (i) cataphoresis, and (ii) high frequency oscillations.

S. S. JOSHI *and* V. S. RAGHAVAN, Benares

It has been shown by Joshi and co-workers (*J. Indian Chem. Soc.*, 1933, **10**, 329; *ibid.*, p. 599; *ibid.*, 1934, **11**, 133; *ibid.*, pp. 55, 573, and 797; *ibid.*, 1936, **13**, 441; *J. Chim. Phys.*, 1935, **32**, 455; *Proc. Acad. Sci.*, 1935, **5**, 41) that contrary to the tacit assumption made by colloid chemists viscosity does not always increase during the progress of a given coagulation. They have also reported (*loc. cit.*) that usually, if not invariably, there is an initial diminution of viscosity for which quite a variety of explanations is to be found in the literature of the subject, the simplest being the adsorption of ions carrying the same kind of charge as the colloids, obtained from the coagulating electrolyte. Our experiments, under (i), show that this initial diminution occurs very frequently when

differently concentrated sols of antimony, arsenious, mercury, cadmium sulphides, ferric hydroxide (both positively and negatively charged), thorium and aluminium hydroxide, manganese dioxide, vanadic acid, prussian blue, silver and copper ferrocyanides, silver, gold, sulphur were subjected to *short* durations of (i) cataphoresis due to continuous potentials, and to (ii) high frequency oscillations produced by a condensed spark discharge. There is a possibility under (i) of ions derived, in part, from the intermicellar medium interacting with the suspended particles under the influence of the applied field and causing coagulation and thus simulating the action of an externally added electrolyte. This factor is, however, almost negligible under (ii), which also shows the initial viscosity change mentioned above.

Continued exposure to (i) and (ii), showed that in all the coagulations thus produced, the viscosity varied discontinuously or '*zonally*' with respect to coagulation time in agreement with our earlier numerous results (*loc. cit.*) in different types of electrolytic coagulations. This general finding also accords fully with previous results obtained in these laboratories in the case of a large number of colloids (Joshi and Subbaiah, *loc. cit.*) subjected to transpiration in very long capillary paths disposed equatorially to electric fields due to alternating potentials at various commercial frequencies.

It is considered that these electro-viscous effects arise out of a mechanical deformation produced, in part, by the *polarization* of the micelle under the applied field; orientation conditioned by the lines of flow at a given rate of shear and the thermal agitation would also appear to be a significant factor. A theory is worked out on the assumption that the partial or complete neutralization of the micellar charge in coagulation when external electrolytes are added, differs in degree but not in kind from (i).

61. Studies of the viscosity of colloids by the oscillating cylinder method during 'slow' coagulations and under fields due to alternating potentials.

D. SUBBA RAO, Benares.

In the course of numerous publications by Joshi and co-workers from these laboratories it has been reported that a marked limitation obtains in the use of viscosity to follow the progress of a given coagulation. In view of the importance of issues involved, it was considered desirable to carry out viscosity measurements for colloids subjected to coagulation by an additional method. The method of the oscillating cylinder which we have adopted in the present work is also free from the excessive rates of shear which obtain in all capillary types of viscometer, used in our earlier work. The arrangement was also convenient to study the influence, on the viscosity of a liquid, of superimposing fields due to alternating potentials.

The following colloids prepared by the usual methods were studied at different dilutions: arsenious sulphide, manganese dioxide, ferric hydroxide, prussian blue, mercuric sulphide, vanadium pentoxide and aluminium hydroxide, (i) in the presence of differently concentrated solutions of KCl, $BaCl_2$, $AlCl_3$ and $Th(NO_3)_4$ and (ii) under the action of the electric fields. η the viscosity was determined by a determination of T the period of oscillation and of λ the logarithmic decrement, produced by giving an extremely small rotational impulse to the inner cylinder immersed in the colloid, from the equation,

$$\eta = \frac{16I^2}{\pi\rho T r^6 (r+2d)^2}\left\{\frac{\lambda-\lambda_0}{\pi}+\left(\frac{\lambda-\lambda_0}{\pi}\right)^2\right\}^2$$

where I is the moment of inertia of the inner cylinder, r its radius and d the height; ρ is the density of the liquid.

These measurements have fully confirmed the earlier findings of Joshi and co-workers that the commencement of a *slow* coagulation is almost always characterized by an initial diminution of η. Furthermore, η varies time-discontinuously or *zonally* during the progress of every one of the coagulations which has been investigated by this method, and that numerous coagulations entailed an overall diminution of η below the initial value, which is contrary to the current view that η should rise during coagulation.

When alternating electric potentials were applied to the inner oscillating cylinder, the outer one being earthed, in every one of the cases studied, the viscosity first *diminished* to a minimum; it remained either at the minimum or showed a subsequent increase on a prolongation of the exposure to the fields.

62. Ageing of molybdic acid sol.

T. BANERJEE, Dacca.

Measurements of viscosity and bound water of freshly prepared and aged molybdic acid sols (conc.—0·025M with respect to molybdate) indicate that hydration plays an unimportant rôle in the ageing of the sol. The result on the effect of irradiation and heating of freshly prepared and aged sols, whereby the particles of molybdic acid decrease in size, go clearly to show that in the case of molybdic acid sol agglomeration of simpler molecules to aggregate molecules can better explain the observed ageing effect.

63. Studies in soap gels in pinene.

MATA PRASAD *and* C. V. VISHWANATH, Bombay.

The times of setting (t) of gels containing different amounts (A) of sodium oleate, sodium palmitate, sodium stearate and potassium oleate in pinene have been measured by Fleming's method, at different temperatures (T). Straight lines have been obtained when (i) values of log A are plotted against log t, and (ii) values of log t are plotted against $\frac{1}{T}$.

The cooling curves of sodium stearate gels in pinene have been studied at different temperatures during sol-gel transformation.

Viscosity measurements of sodium oleate gels in pinene have been made by Falling sphere method at different temperatures with different amounts of the gelling substance during setting. When values of viscosity are plotted against time straight lines are obtained and the straight lines for different sodium oleate content of the gels are almost parallel to one another.

64. Hysteresis in sorption. I. Permanence of the hysteresis loop. Titania gel-water system.

K. SUBBA RAO, Bangalore.

A technique involving the use of a McBain-Bakr spring balance of quartz fibre has been employed in the study of hysteresis in sorption.

In the sorption of water at 30°C., titania gel exhibits a hysteresis loop which is of remarkable permanence and reproducibility, the hysteresis loop having been traced after thirty-two sorptions and desorptions. Such a hysteresis loop is satisfactorily explainable only on the basis of the concept of cavities with constricted ends.

After four and half months from the commencement of the first sorption, the hysteresis loop suffers a 'drift', which indicates a structural change in the gel resulting in the variation of the size of the capillaries.

65. Hysteresis in sorption. II. Scanning of the hysteresis loop. Titania gel-water system.

K. SUBBA RAO, Bangalore.

Application to the sorption and desorption isotherms of water on titania gel at 30°C. (*cf.*, Part I), of the Langmuir and Williams-Henry equations for monomolecular adsorption, shows a clear transition from monomolecular adsorption to capillary condensation.

The hysteresis loop has been scanned by traversing it from various intermediate points on the sorption and desorption curves forming the hysteresis loop. The scanning of the loop has revealed the following characteristics:—

(*a*) From any point on the main sorption curve if desorption is effected the main desorption curve is reached.

(*b*) But from any point on the main desorption curve, if sorption is effected the main sorption curve is not reached but a separate curve is traced till the peak of the hysteresis loop is reached.

These characteristics focus on to the concept of cavities with constricted ends as a general cause of hysteresis in sorption.

The mechanism of the processes of filling and emptying of cavities has been considered.

Different ways of reaching a point on the main sorption and desorption curves forming the hysteresis loop have been indicated.

The results on the scanning of the loop indicate that a cavity completely filled with water, gets emptied only when it is exposed to a relative humidity less than what is required for water condensed at the neck of the cavity to be in equilibrium with the water vapour.

In accordance to the cavity concept, the true equilibrium curve is the sorption curve, because along the desorption curve the cavities retain the liquid in a metastable equilibrium.

66. Hysteresis in sorption. III. Permanence and scanning of the hysteresis loop. Silica gel-water system.

K. SUBBA RAO, Bangalore.

In the sorption of water at 30°C., silica gel has exhibited a hysteresis loop which remains permanent and is perfectly reproducible, the loop having been traced at the nineteenth sorption and desorption.

The hysteresis loop has been scanned by traversing it from various points on the sorption and desorption curves. The scanning of the loop has revealed certain characteristics which are in conformity with those of titania gel-water system (*cf.*, Part II). These characteristics form a convincing proof of the concept of cavities with constricted ends as a general cause of hysteresis in sorption.

A comparison of the hysteresis loops of silica gel-water and titania gel-water systems has been made.

67. Hysteresis in sorption. IV. Permanence and scanning of the hysteresis loop. Silica gel-carbon tetrachloride system.

K. SUBBA RAO, Bangalore.

A series of sorptions and desorptions of carbon tetrachloride at 30°C. on silica gel have exhibited a hysteresis loop of remarkable permanence and reproducibility, the loop having been traced at the eighth sorption and desorption.

A comparison of the hysteresis loop with that of silica gel-water system, as regards the shape and size of the loops, has been made in the light of the cavity concept.

The permanent and reproducible hysteresis loop has been scanned by traversing the loop from various intermediate points on the sorption and desorption curves.

The general characteristics as revealed by scanning of the hysteresis loop are in conformity with those of silica gel-water (*cf.*, Part III) and titania gel-water (*cf.*, Part II) systems. These characteristics are quite independent of the nature of the adsorbent and the adsorbate but are solely connected with the shape and size of the cavities. They point to the cavity concept as the general explanation of the hysteresis effect in sorption.

68. Hysteresis in sorption. V. Permanence, scanning and drift of the hysteresis loop. Ferric oxide gel-carbon tetrachloride and ferric oxide gel-water systems.

K. SUBBA RAO, Bangalore.

A series of sorptions and desorptions of carbon tetrachloride at 30°C. on ferric oxide gel has shown a permanent and reproducible hysteresis loop, the first, second and third hysteresis loops being identical.

The permanent and reproducible hysteresis loop in ferric oxide gel-carbon tetrachloride system has been scanned by traversing the loop from various intermediate points on the sorption and desorption curves. The characteristics of the results are in conformity with those of titania gel-water (*cf.*, Part II), silica gel-water (*cf.*, Part III) and silica gel-carbon tetrachloride (*cf.*, Part IV) systems. These characteristics being independent of the nature of the adsorbent and the adsorbate but depending solely on the shape and size of the cavities in the porous adsorbent, point to the cavity concept as the general explanation of hysteresis in sorption.

In the sorption of water vapour at 30°C. ferric oxide gel exhibits a hysteresis loop which as a result of successive sorptions and desorptions reveals several unique and interesting phenomena such as:—

(*a*) The continuous decrease in the sorptive capacity at saturation pressure indicating a decrease in the total capillary volume.

(*b*) The decrease in the area of the hysteresis loop indicating a decrease in the cavity volume.

(*c*) The drift of the hysteresis loop, away from the axis other than that of pressure indicating a widening of the cavities and their necks.

(*d*) The tail end of the hysteresis loop terminating away from the zero pressure indicating the widening of all the molecular necks.

(*e*) The retention by the gel of a definite amount of water irreversibly, at the end of first desorption.

In the light of the cavity concept, the above interesting phenomena reveal the coalescence of the colloidal particles of ferric oxide gel, into bigger aggregates, during successive sorptions and desorptions.

69. Hysteresis in sorption. VI. Disappearance of the hysteresis loop. The rôle of elasticity of organo-gels in hysteresis in sorption. Sorption of water on some cereals.

K. SUBBA RAO, Bangalore.

A series of sorptions and desorptions of water vapour at 30°C. on activated rice and dhal grains have revealed the unique colloidal behaviour, namely the disappearance of the hysteresis loop initially exhibited.

An explanation of this phenomenon, based on the cavity concept, has been offered. By virtue of their property of swelling on the imbibition of water, the grains become elastic and consequently the cavities with elastic walls lose their property of entrapping water. This results in the disappearance of the hysteresis effect.

A series of sorptions and desorptions of carbon tetrachloride at 30°C. on the activated rice grain has shown a permanent and reproducible hysteresis loop.

There has been a striking similarity, in the behaviour, in regard to hysteresis in sorption of grains like rice and dhal and plant exudate like gum arabic.

The investigations on the few typical organo-gels have revealed the rôle, in the disappearance of the hysteresis loop in sorption, of the elasticity of organo-gels which swell on the imbibition of water.

70. Hysteresis in sorption. VII. Scanning of the hysteresis loop. Alumina gel-water system.

K. Subba Rao, Bangalore.

In the sorption of water vapour at 30°C. alumina gel exhibits a permanent and reproducible hysteresis effect.

The hysteresis loop has been scanned by traversing the loop from various intermediate points on the sorption and desorption curves. The characteristics of the results on scanning are in conformity with those of titania gel-water (*cf.*, Part II) and silica gel-water (*cf.*, Part III) systems. These characteristics which are explicable only on the idea of cavities having narrow necks, point to the cavity concept as the general explanation of the hysteresis effect in sorption.

71. On Donnan membrane equilibrium.

S. G. Chaudhury, Calcutta.

By the application of the distribution law of Boltzmann to systems in membrane equilibrium it has been shown that for the theory of the Donnan membrane equilibrium to hold good, it is necessary that E_m, the membrane potential, should be negligibly small under the conditions of experiments. When $\frac{E_m F}{RT} << 1$, where E_m is the membrane potential, R, T, and F have their usual significance, it has been found that

$$(C+)_1 + (C-)_1 = (C+)_2 + (C-)_2$$

where $(C+)_1$ and $(C-)_1$ are the concentrations of positive and negative ions in the colloid compartment and $(C+)_2$ and $(C-)_2$ are the concentrations of the respective ions in the other compartment. When $\frac{E_m F}{RT}$ is greater, we have $(C+)_2 + (C-)_1 = \left\{(C+)_2 + (C-)_2\right\} \cosh \frac{N^{*\prime} E_m F}{RT}$, where $N^{*\prime} = N_1 = N_2$ or $(N_1 N_2)^{\frac{1}{2}}$. N_1 and N_2 are the values of positive and negative ions.

72. Adsorption from the binary system benzene-ethyl-alcohol.

(Miss) Nagamani Shama Rao *and* S. K. K. Jatkar, Bangalore.

The selective adsorption of the components of this system shows 'S' type of curves for sugar charcoal (activated by H_2 and CO_2) and for

silica gel and blood charcoal. 'U' type of curves were obtained in the case of sugar charcoal (activated in steam and CO_2) and norit. The shape of the adsorption isotherms is explained on the basis of complex formation and association of polar molecules to form non-polar ones. The maxima in the selective adsorption of this system occur at the composition corresponding to C_6H_6, $3C_2H_5OH$, indicating the complex formation between the associated alcohol molecules with one of benzene.

73. Adsorption from the binary system benzene-acetic acid.

(MISS) NAGAMANI SHAMA RAO *and* S. K. K. JATKAR, Bangalore.

The selective adsorption curves of acetic acid from benzene solutions in the entire range of concentration on (i) sugar charcoal and (ii) blood charcoal, were of 'S' type passing through a negative maximum at composition corresponding to C_6H_6, $2(CH_3COOH)_2$ and a positive maximum at C_6H_6, $(CH_3COOH)_2$. It is interesting to note that the polarization curve for this system passes through a maximum at the former composition.

Silica gel gives an inverted 'U' type of curve, acetic acid being preferentially adsorbed. The curve passes through a maximum when the composition is C_6H_6, $(CH_3COOH)_2$. It appears from these results that acetic acid molecules can form loose co-ordinate compounds with benzene.

74. Study of base-exchange reactions and buffer curves of Indian red and laterite soils.

S. P. RAYCHAUDHURI *and* P. K. BASURAICHAUDHURI, Dacca.

In the present paper the chief base-exchange properties of a number of profile samples of red and laterite soils of India have been studied. This includes the study of pH, percentages of air-dry moisture, percentages of degree of saturation, buffer curves and the influence of the percentages of free alumina, free iron oxide, free silica and percentages of organic carbon on the nature of buffer curves. Buffer curves were also studied with minerals like limonite, bauxite, halloysite, kaolin, and montmorillonite and with ignited and non-ignited electrodialyzed gels of iron oxide, alumina and silica and with Merck's humic acid. The relative absorbabilities of Li, K, Na and Ca by ordinary air-dry and electrodialyzed soils have been compared. In order to observe closely the effect of free silica, free alumina and free iron oxide on the nature of buffer curves, three soil samples were treated by the method of Truog and co-workers and the buffer curves of the residues have been compared with those of original soils. The results show in general that the material which is responsible for base-exchange reactions and buffer capacities is accumulated in varying amounts at different layers of the profiles. The manner of variation of this active soil material down the profiles may prove useful in soil survey and soil classification. It has been suggested tentatively that the following substances which may be present in the soil to greater or less extent may be responsible for the buffer values of the soil at different pH ranges:—alumina, oxide of iron, humic acid, and silica. The relative adsorbabilities of alkali metal cations from their buffered solutions by soils follow generally the well-known lyotropic series K>Na>Li. The removal of free sesquioxides and free silica from the soils increase the buffer capacities of the residues.

75. Studies in the physico-chemical changes in the black cotton soil during nitrification.

MATA PRASAD *and* N. K. PATWARDHAN, Bombay.

Nitrification, in the Black Cotton Soil from the Malwa Plateau due to the added ammonium sulphate at 25 lbs. and 50 lbs. N-equivalent

per acre, under laboratory conditions (pot experiments) during the Bombay monsoon, has been followed by the study of the physico-chemical properties.

With the advance of the nitrification there is an increase in the hygroscopic moisture, the exchangeable calcium, the exchange capacity, the organic carbon and the C/N ratio in the first two months from the start, but in the next two months these values once again decrease and come back to the normal. The exchangeable sodium and potassium decrease continuously throughout the experimental period, on account of treatment, while the amount of the exchangeable magnesium is not affected. The clay contents of the soil remain fairly constant.

When small doses of ammonium sulphate are administered there is in general no deterioration in the soil structure. But the improved crop yields lead to the conclusion that the fertility of the soil is definitely increased.

76. The properties of clay salts.*

S. K. MUKHERJEE, Calcutta.

Clays saturated with metal ions may be looked upon as clay salts. Clay salts prepared from hydrogen clays obtained from two acid soils have been used in this present study which deals with the following topics: (1) The variation of the specific conductivity (sp. cond.) and cataphoretic speeds (c.v.) of particles with the concentration of the colloidal salt. (2) Interaction of clay salts with hydrochloric acid.

The variations of sp. cond. and c.v. with the concentration of the clay salt are not linear and the curves run concave towards the concentration axis. The interaction of the clay salts with hydrochloric acid was studied by means of potentiometric titrations. The exchange of cations for H^+ ions as calculated from the amount of acid required to reach the inflexion point in the titration curve follows the order of the *irregular cation effect*. This is expected in view of the fact that the interaction with HCl takes place mainly in the region between pH 8·5 and 6·0. These pH values correspond to the average pH values of the clay salts and the pH near about which inflexion occurs. In this region the order of adsorption of cations is that of the irregular cation effect observed in the interaction of bases with hydrogen clays. The variation of silver ion concentration determined electrometrically with dilution of silver clay is not linear but the curve runs concave towards the axis of concentration.

77. Variations in the properties of sub-fractions of hydrogen bentonites with the particle size.*

R. P. MITRA *and* SHANKARANANDA MOOKERJEE, Calcutta.

In continuation of previous work on sub-fractions of hydrogen clays (Mitra and Chakravarty, *Proc. 26th Ind. Sci. Cong.*, III, p. 184, 1939) a study has been made of the variations in the properties of six sub-fractions of a bentonite from Hati-ki-dhani having mean particle sizes 0·75μ(I), 0·38μ(II), 0·18μ(III), 0·08μ(IV), 0·038μ(V), and $<$0·025μ (VI). The hydrogen bentonites prepared from these sub-fractions by repeated treatment with a dilute mineral acid have, like the hydrogen clays, a pronounced acid character. They give characteristic titration curves with bases which have more or less the same form with the exception of fraction V. The total neutralizable acid in milliequivalents of base per 100 grams of the oven-dried colloid calculated at the inflexion point of the titration curves tends to increase as the particle size decreases.

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* The work has been carried out under a scheme of research financed by the Imperial Council of Agricultural Research, India.

The coarsest and the finest fractions have total acids 49·5 and 75·0 with NaOH. Fractions II, III, and IV have nearly the same total acid which is about 60·0. The total acid of fraction V is 55·0 which is somewhat smaller than the next three coarser fractions. The chemical composition of this fraction is different from that of the others which have nearly the same composition. Unpublished work of S. N. Bagchi from this laboratory further shows that fraction V has a mean refractive index and appearance under the microscope quite different from those of the other fractions. The analytical, electrochemical and optical data thus all point to a different mineralogical make-up of fraction V compared to the other fractions.

The total acid (T_A) per sq. cm. of the external surface of the fractions calculated assuming spherical particles does not remain constant (even for fractions II, III, IV, and VI which have practically the same chemical composition) as would be expected if the reaction with the base were confined to the surface. On the other hand, T_A increases with the particle size indicating that the particles have considerable inner surfaces and/or fresh layers are continually made available as the outer layers react with the base. An almost complete dissolution of the finest fraction was observed on titrating with NaOH to pH 9·0.

Organic Chemistry

78. Studies in long-chain acids (IV): On an attempted synthesis of aleuritic acid.

P. C. Mitter *and* S. M. Mukherji, Calcutta.

On oxidation with Caro's acid, cyclohexanone gave ω-hydroxy hexoic acid, the ethyl ester of which gave, on treatment with PBr_3 the corresponding bromoester B.P. 125°–127°/15 mm. On treatment with sodium methoxide in methyl alcohol, this gave ethyl ω-methoxy hexoate B.P. 94°–94°/51 mm. The ester, on Bouveault reduction with sodium and ethyl alcohol, gave ω-methoxy hexyl alcohol B.P. 112°/18 mm. in 66% yield. The above alcohol was converted into the corresponding bromide B.P. 98°-99°/19 mm., with phosphorus tribromide and pyridine.

The Grignard compound corresponding to the above, was condensed with 9-methoxy 8, 9-dibromo nonyl chloride, prepared according to the method of Noller and Bannerot (*J.A.C.S.*, 1934, **56**, 1563). The condensation product was dissolved in butyl alcohol and refluxed with zinc dust for ten hours. After removal of zinc, the residue was washed with dilute hydrochloric acid and then with water, dried and then subjected to fractional distillation.

$CH_3OCH_2(CH_2)_5CH{=}CH(CH_2)_7Cl$ was found in the fraction boiling at 198°–204°/6 mm.

79. Stereoisomerism of cyclohexane derivatives. The synthesis of 4-methylcyclohexane-1 : 1-dicarboxylic and 3-methylcyclohexane-1 : 1-dicarboxylic acids. An evidence for the multiplanar forms of the cyclohexane ring.

R. D. Desai *and* G. S. Sahariya, Bombay

Each of the acids mentioned in the title of the paper has been isolated in two stereoisomeric forms. This fact can only be explained on the assumption that the cyclohexane ring is multiplanar. The previous attempts of the authors in collaboration with Dr. R. F. Hunter to prepare

the strainless modifications of 1-carboxy-4-methyl, -3-methyl- and—2-methylcyclohexane-1-acetic acids were not successful as only two forms could be isolated in each case.

80. The chemistry of alkyl-cyclopentanones. Part IV. Synthesis of 1-carboxy-3-methylcyclopentane-1-α-benzylacetic, 1-carboxy-cyclopentane-1-α-benzylacetic and 1-carboxy-cyclopentane-1-α-propionic acids.

R. D. Desai and G. S. Sahariya, Bombay.

By the action of benzyl chloride and methyl iodide on the sodio-derivatives of the dicyano esters obtained by condensing ethyl-sodio-cyanoacetate with the cyanohydrins of cyclopentanone and 3-methyl cyclopentanone, and hydrolyzing the resulting esters with dilute sulphuric acid, the acids mentioned in the title of this paper are obtained. These acids were prepared for instituting a comparison with their cyclohexane and alkylcyclohexane analogues prepared by the authors in collaboration with Dr. R. F. Hunter.

81. Condensation of *d*-camphorcyanohydrin with aromatic amines.

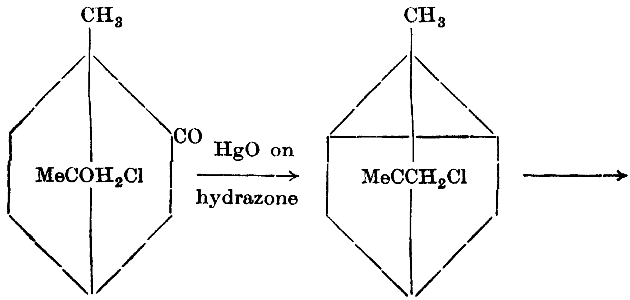
T. R. Chandrashekhar and R. D. Desai, Bombay.

Desai, Kamal, and Momin (*Jour. Univ. Bombay*, 1937, **6** (2), 85) have described the condensation of various arylamines with *d*-camphorcyano-hydrin. These observations have now been repeated with *d*-camphor-cyanohydrin, which has been found to condense less readily than the inactive modification. The molecular rotation of the various 1-arylamino-camphane has been measured, and it has been observed that though these compounds have the dextro rotation, their carbamyl derivatives gave invariably the laevo-rotation.

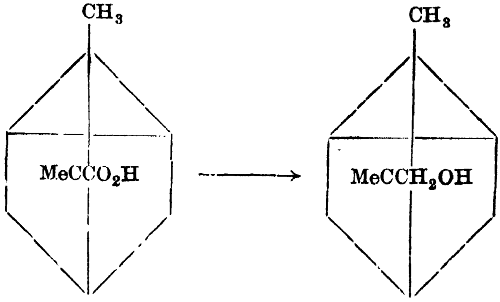
82. On synthesis of santalol and related compounds.

P. C. Guha and A. Kuppuswami, Bangalore.

With the ultimate object of synthesizing the sesquiterpene alcohol, santalol, the synthesis of some of its simpler degradation products, viz. teresantalic acid, teresantalol, etc., has been undertaken. Camphor has been sulphonated to give camphor 8-sulphonic acid, the sodium salt of which on treatment with PCl_5 gives camphor sulphonyl chloride (Kipping and Pope, *J.C.S.*, 1893, **63**, 553; 1895, **65**, 357, 377). It has been converted to 8-chloro-camphor (I) by the application of heat. Conversion of (I) into the chlorotricyclene derivative (II) and also into teresantalic acid (III) and teresantalol (IV) is being investigated.



(I) (II)



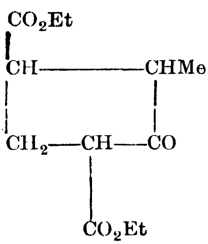
(III) (IV)

83. On a new method of synthesis of the norbornylane system.

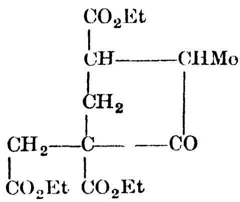
P. C. Guha *and* V. R. Srinivasan, Bangalore.

The sodium derivative of ethyl malonate was condensed with ethyl α-bromopropionate to give the ethyl ester of propano-1 : 1: 2-tricarboxylic acid (I). The sodium derivative of (I) in turn was condensed with ethyl β-bromopropionate to give the corresponding tetracarboxylic ester (II) (b.p. 177–80°/2-3 mm.). Hydrolysis and decarboxylation of (II) gave the corresponding tricarboxylic acid (m.p. 180°). The acid was esterified and cyclized to the corresponding cyclopentane derivative (III) (b.p. 150–53°/2–4 mm.). The sodium derivative of (III) was then condensed with ethyl bromoacetate to give the corresponding cyclopentane derivative. This on hydrolysis and decarboxylation gave an acid (IV) (m.p. 207°).

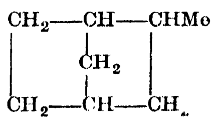
The ethyl ester of (IV) is being cyclized to a norbornylane derivative (V).



(III)



(IV)



(V)

84. A theory of colour on the basis of molecular strain. Part III.

Sikhibhushan Dutt, Allahabad.

In accordance with a 'Theory of colour on the basis of molecular strain' advanced by the present author, the true nitroso group (N = O) is the most fruitful source of intense colour amongst organic compounds due to the high degree of molecular strain contained therein. For this reason, the nitroso group has always a tendency to lose the internal strain by oxidation, reduction or by the formation of an isonitroso compound by migration of a labile hydrogen atom in vicinity. But under certain

circumstances, a weakly strained isonitroso compound may pass into a highly strained nitroso compound with consequent development of intense colour, by the same process of migration of a hydrogen atom, whereby an oximino-ketonic structure gets converted into a nitroso-enolic structure. This structural change takes place by the action of alkalies and organic bases, whereby the weakly acidic oximino-ketonic form becomes converted into a strongly acidic nitroso-enolic form, which latter becomes stabilized by salt formation.

From a study of a large number of isonitroso compounds, the present author has come to the conclusion that wherever there are a number of possibilities of tautomerism of the oximino-ketonic form into the nitroso-enolic form, the greatest development of colour is produced.

85. Halogenation. Part XXXIII. Halogenation of α-methyl-naphthalene.

P. S. VARMA *and* P. R. BHATTACHARYA, Benares.

This paper describes a few experiments on the direct halogenation of methyl-naphthalene and 4-bromo-1-methyl naphthalene. 1-Methyl naphthalene gives on chlorination with chlorine (1 mol.) in presence of aluminium chloride, 4-chloro-1-methyl naphthalene, b.p. 177–180°/13 mm., picrate, m.p. 104-105° and with bromine in presence of iron in sunlight 4-bromo-1-methyl naphthalene, b.p. 155–160°/9 mm., picrate, m.p. 125-126°. On iodination with iodine in presence of sodium persulphate, 4-iodo-1-methyl naphthalene, b.p. 162–166°/11 mm., picrate, m.p. 96–98° and also 2-iodo-1-methyl naphthalene, b.p. 183–189°/11 mm., picrate, m.p. 106–108°, the latter obtained before from 2-amino-1-methyl naphthalene (Scholl and Montash, 1918, **39**, 231–236).

With chlorine (1 mol.) 4-bromo-1-methyl naphthalene gives 4-bromo-5-chloro-1-methyl naphthalene, m.p. 72-73°, b.p. 185°–190°/9 mm. while with bromine (1 mol.) at 100°, 4 : 5-dibromo-1-methyl naphthalene, m.p. 100-101° is obtained. 4-Bromo-5-iodo-1-methyl naphthalene, b.p. 200–203°/16 mm. is prepared by iodinating 4-bromo-1-methyl naphthalene with iodine in presence of sodium nitrite and fuming sulphuric acid. 4-Bromo-1-methyl naphthalene at 250–260° gives 4-bromo-1-naphthyl methyl chloride, b.p. 205–212°/13 mm.

86. C-alkyl resorcinols. Part IV. The mechanism of nuclear alkylation of polyhydric phenols by alkali and alkyl iodide.

R. C. SHAH, Bombay.

The mechanism of nuclear alkylation of polyhydric phenols by alkali and alkyl iodide, for which no explanation has been hitherto available, is suggested. The reaction essentially consists in the addition of alkyl iodide to the double bond between the carbon atom bearing the hydroxyl group and the neighbouring carbon atom. This also satisfactorily explains the alkylation in the 2-position which takes place in the case of reacetophenone methyl β-resorcylate, β-resorcylaldehyde, etc., this being due to the fixation of the double bond by chelation between the hydroxyl group and a group like acetyl or carbethoxy.

87. On a new method for the preparation of tertiary amines Part I: *n*-Propylbenzylaniline.

BAWA KARTAR SINGH, Allahabad, *and* PARMESHWARI PRASAD, Patna.

The method was originally described by one of us (Singh, *Trans. Chem. Soc.*, 1916, **109**, 780) and the work is a continuation of that carried

out in conjunction with M. K. Srinivasan (unpublished). In the present paper, *n*-propylbenzylaniline and its salts, e.g. picrate, hydrochloride, platinichloride and the methoiodide as described.

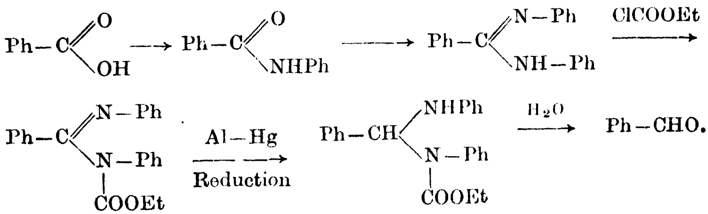
The reaction, on which the preparation of the tertiary amine is based, incidentally illustrates that a quinquevalent nitrogen atom cannot be joined to five positive or hydrocarbon radicles: one of them must be an electronegative element or group.

The present work affords the strongest evidence that the co-valency of nitrogen is limited to four.

88. A general method for the conversion of an aromatic carboxylic acid to the corresponding aldehyde.

M. V. SHIRSAT *and* R. C. SHAH, Bombay.

A new method for the conversion of an aromatic carboxylic acid to the corresponding aldehyde, has been previously reported (Ghadiali and Shah, *Ind. Sci. Cong.*, 1936 Abs.). Thus benzoic acid has been converted into benzaldehyde through the following stages:—



The method has now been tested with a number of differently substituted benzoic acids. It has been found to be of general applicability, the yields being satisfactory throughout. It is noteworthy that it can be successfully used even for the preparation of hydroxy aldehydes, with the modification that the acid is methylated and converted into the methoxy-benzamidine, which is demethylated by $AlCl_3$ to the hydroxy-benzamidine.

89. Synthesis of aldehydo-hydroxy-benzoic and -naphthoic acids.

(MISS) K. S. RADHA, R. D. DESAI, *and* R. G. SHAH, Bombay.

The synthesis of 2 : 4-dihydroxy-5-aldehydo-benzoic acid by the action of hexamethylene tetramine on methyl-β-resorcylate has been previously reported (*Proc. 27th Ind. Sci. Congress*, 1940, p. 76). The formylation by hexamethylene tetramine of methyl ester of pyrogallol carboxylic acid, methyl 1-hydroxy-2-naphthoate and methyl 2-hydroxy-3-naphthoate has now been successfully studied. The products are shown to have the constitutions of 2 : 3 : 4-trihydroxy-5-aldehydo-benzoic acid, 1-hydroxy-4-aldehydo-2-naphthoic acid and 1-aldehydo-2-hydroxy-3-naphthoic acid respectively.

90. Synthesis of β-β-disubstituted acrylic acids.

R. D. DESAI *and* (MISS) K. S. RADHA, Bombay.

β-Ketonic esters react readily with phenols in presence of various condensing agents giving coumarins. It was thought that if the aromatic hydrocarbons themselves were made to react with these ketonic esters

in the presence of certain condensing agents, the reaction would afford a good method of synthesizing di- and trisubstituted acrylic acids. It was only in the presence of anhydrous aluminium chloride that benzene, toluene, *m*-xylene, *p*-xylene and naphthalene reacted with aceto-acetic ester giving the expected acrylic acids. However, the yields of the various condensation products were not satisfactory. We are extending this reaction to cyclic as well as to other β-ketonic esters.

91. Studies in the Friedel-Craft's reaction. Part VII. Condensation of polyhydroxy phenols with acid anhydrides.

R. D. DESAI, H. FIGUEREDO, *and* (MISS) V. M. VAKIL, Bombay.

Though phenolic ethers have been recently extensively condensed with dibasic acid anhydrides, their direct condensation with poly hydroxy-phenols has not been studied with exception of Ullmann and co-workers (*Ber.*, 1919, **52**, 2098; 1920, **53**, 830).

We have found that resorcinol and orcinol can be easily condensed with succinic as well as phthalic anhydrides with the formation of their respective keto-acids. These acids have been reduced, brominated and methylated. The efforts to condense pyrogallol, phloroglucinol, hydroquinone, dimethylaniline, acetanilide, resaceto-phenone, and methyl-resorcylate with these anhydrides failed.

92. Studies in naphthalene series. Part VIII. The synthesis of 4-lauryl-4-palmityl and 4-stearyl-1-naphthols.

R. D. DESAI *and* W. S. WARAVDEKAR, Bombay.

Three methods have been tried to synthesize the above naphthol-ketones: (1) Action of the respective acid chlorides on α-naphthol in presence of zinc chloride. (2) Action of the acid chlorides on α-naphthyl methyl ether and subsequent demethylation. (3) Condensation of 2-acetyl-1-naphthol with acid chlorides and elimination of the acetyl group. It is found that the third method gives the best yield of the desired compounds. Various interesting products during the course of the study of the first two methods were isolated and their reactions studied.

93. Syntheses of *o*-methoxy and *o*-chloro phenyl succinic acids.

R. H. SIDDIQUI, Aligarh.

o-Methoxy benzaldehyde was condensed with ethyl cyanacetate in presence of piperidine. The benzylidene derivative, obtained in light yellow needles, had m.p. 77°. This on condensation with KCN gave ethyl a-β-dicyano-β-*o*-methoxy phenyl propionate, m.p. 85°. This ester on hydrolysis yielded *o*-methoxy phenyl succinic acid, m.p. These stages are compared with the corresponding stages of phenyl succinic and *p*-methoxy-phenyl succinic acids and some of their derivatives are prepared. Likewise *o*-chlorophenyl succinic acid is prepared from *o*-chlorobenzaldehyde and had m.p. 155°.

94. The condensation of malonanilic acid with *o*-, *m*- and *p*-hydroxybenzaldehyde.

P. I. ITTYERAH *and* K. C. PANDYA, Agra.

In an earlier paper (Mehra and Pandya, *Proc. Ind. Acad. Sci.*, A, 1938, 7, 369) the condensations of several aldehydes, including the above three, were studied by two different methods, and the advantage of the pyridine-trace method was evident. In the case of the three hydroxybenzaldehydes, the products of the condensations were always the decarboxylated

anilide and never the benzylidene-malonanilic acid, no matter whether the pyridine was in traces or in larger amounts, according to Robinson's method. As the decarboxylation may be due to the base as well as to the temperature employed, an attempt has been made to obtain the acids by using a lower temperature and using no base at all.

m- and *p*-hydroxybenzylidene malonanilic acids in very fair yields are thus obtained. The *o*-isomer gave only the anilide, as probably the ring is closed.

In contrast to this, unsubstituted benzaldehyde gave up to 87% yield of the acid under the same conditions.

95. Condensation of malonanilic acid with *o*-, *m*- and *p*-nitrobenzaldehydes.

P. I. Ittyerah *and* K. C. Pandya, Agra.

The nitrobenzaldehydes have also been studied (Mehra and Pandya, *loc. cit.*), their condensations in the presence of a trace of pyridine giving good yields of the anilides only. Now condensed in the absence of any base, the three aldehydes give products which, in each case, are a mixture of the acid and the anilide. The *m*-α-*p*-nitrobenzylidene malonanilic acids come out in good yields (about 75%) mixed with 20–25% of the anilide. The *o*- analogue is in much smaller yield and is identical with that reported by Ahluwalia, Haq, and Ray (*J.C.S.*, 1931, 2059).

96. Condensation of malonanilic acid with *o*-, *m*- and *p*-methoxybenzaldehydes.

P. I. Ittyerah *and* K. C. Pandya, Agra.

The condensations of malonanilic acid with the three methoxy-benzaldehydes are studied, under different conditions, (i) by Robinson's method as applied by Ray and co-workers (*loc. cit.*), (ii) by our pyridine-trace method, and (iii) in the absence of any condensing reagent.

As in the earlier condensations the trace method gives the highest yields. Secondly, when a base is present, in a trace or in larger proportions, the product is mainly or exclusively the anilide, and when no condensing base is present the product is mainly or exclusively the acid. Thirdly, the inhibiting effect of the hydroxy group is now removed, and the best yields in these cases are above 90%.

All these products are purified and analyzed easily.

97. Influence of a trace of pyridine on the condensations of *m*- and *p*-chlorobenzaldehydes and *m*-bromobenzaldehyde.

K. C. Pandya *and* (Miss) Rashmi Bala Pandya, Agra.

Condensations of *m*- and *p*-chlorobenzaldehydes and of *m*-bromobenzaldehyde with malonic acid in the presence of a trace of pyridine have been studied. The unsubstituted benzaldehyde under the same conditions give an yield of 95% of cinnamic acid. The three halogen-substituted benzaldehydes give quantitative yields, and do so very quickly, often within one hour.

Lock and Bayer (*Ber.*, 1939, **72**, 1064) have reported on the influence of the group in substituted benzaldehydes in the condensations carried out under standardized conditions by Perkin's method. According to them the unsubstituted benzaldehyde gave only 49% yield of cinnamic acid, the *p*-chloro- gave a slight increase, 52%, the *m*- gave 63, and the *o*-chloro- gave the highest, 71%.

The pyridine-trace method gave incomparably better results.

Corresponding dibasic acids, i.e. the benzylidene malonic acids are also prepared, for the first time, by a modification of the process.

So also these aldehydes condense with malonanilic acid, in the presence as well as absence of pyridine, and give new substituted malonanilic acids and cinnamanilides, corresponding to the aldehydes.

It is intended to continue the work with the other halogen-substituted benzaldehydes.

98. Synthesis of β-(2 : 4-dimethoxy-phenyl)-glutaconyl-acetic acid.

V. K. BAVADEKAR, Poona.

β-(2 : 4-dimethoxy-phenyl)-glutaconic acid, (I), $C_{13}H_{14}O_6$, m.p. 174°, has now been prepared in one step from 7-hydroxy-coumarin-4-acetic acid (*cf.*, Limaye, *Proc. Ind. Sci. Congress*, 1932, 226). (I) gives an anhydride, $C_{13}H_{12}O_5$, m.p. 144°, titrating as a monobasic acid, an acid ethyl ester, $C_{15}H_{18}O_6$, m.p. 91°, an acid methyl ester, $C_{14}H_{16}O_6$, m.p. 110°, and a semianilide, $C_{19}H_{19}O_5N$, m.p. 165°.

(I) gives on condensation with sodium acetate and acetic anhydride, (*cf.*, Limaye and Bhave, *Journ. Univ. Bombay*, 1933, **2**, II, 82), β-(2 : 4-dimethoxy-phenyl)-glutaconyl-acetic acid, $C_{15}H_{14}O_6$, m.p. 130°, (II). (II) by loss of CO_2 gives β-(2 : 4-dimethoxy-phenyl)-methylene-glutaconide, $C_{14}H_{14}O_4$, m.p. 104°, (III). Both (II) and (III) yield on hydrolysis with dilute alkali, β-(2 : 4-dimethoxy-phenyl)-γ-aceto-vinyl-acetic acid (IV), (semicarbazone, $C_{15}H_{19}O_5N_3$, m.p. 163° decomp.) (IV) on treatment with acetic anhydride or hydrochloric acid regenerates (III).

99. Extension of the Nidhone process for the syntheses of 2-acyl-resorcins to 2-benzoyl-4-ethyl-resorcin.

S. H. MEHTA, Poona.

The Nidhone process for the syntheses of 2-acyl-resorcins (D. B. Limaye, *Ber.*, 1934, **67**, 12) has been extended to the synthesis of 2-acetyl-4-ethyl-resorcin (S. D. Limaye, *Proc. Ind. Sci. Congress*, 1939, II, 105). The process is now used for the synthesis of 2-benzoyl-4-ethyl-resorcin.

Benzoate of 6-ethyl-4-methyl-umbelliferone, m.p. 155°, gave on treatment with anhydrous aluminium chloride (Fries migration), 8-benzoyl-6-ethyl-4-methyl-umbelliferone, (I), m.p. 159°, $C_{19}H_{16}O_4$. (I) gave its acetate m.p. 152° and benzoate m.p. 189°. On hydrolysis with sodium hydroxide (I) yielded 2-benzoyl-4-ethyl-resorcin, (II), m.p. 120°, $C_{15}H_{14}O_3$, acetone and CO_2. Unlike 2-ethyl-4-benzoyl-resorcin, m.p. 194°, (S. D. Limaye, Ph.D. Thesis, Bombay University, 1940), (II) condensed with acetoacetic ester in the presence of concentrated sulphuric acid—a behaviour in keeping with that of 2-acyl-resorcins.

Condensation of (II) with sodium acetate and acetic anhydride has yielded a product, m.p. 151°, which is under investigation.

100. Syntheses of (2 : 4-dialkoxy-phenylene-1 : 5)-*bis*-glyoxylic acids.

P. J. C. DESOUZA, Poona.

Oxidation of the dimethyl ether of 4 : 6-diacetyl-resorcin (Eijkmann *et al, Chem. Zentr.*, 1905, **1**, 815), with $KMnO_4$, gave a new acid, $C_{12}H_{10}O_8$, m.p. 225°, in addition to the known 3-carboxy-4 : 6-dimethoxy-phenyl-glyoxylic acid, $C_{11}H_{10}O_7$, m.p. 243°. The new acid has been assigned the constitution (2 : 4-dimethoxy-phenylene-1 : 5)-*bis*-glyoxylic acid, (I), since on further oxidation with hydrogen peroxide it gave the known 4 : 6-dimethoxy-*iso*phthalic acid, m.p. 266°.

(I) gave a dimethyl ester, $C_{14}H_{14}O_8$, m.p. 175°, and a diethyl ester, $C_{16}H_{18}O_8$, m.p. 138°.

Similarly, (2 : 4-diethoxy-phenylene-1 : 5)-*bis*-glyoxylic acid, $C_{14}H_{14}O_8$, m.p. 254°, and (2-methoxy-4-ethoxy-phenylene-1 : 5)-*bis*-glyoxylic acid, $C_{13}H_{12}O_8$, m.p. 240°, have been prepared.

The new acids are being utilized for the synthesis of corresponding dialdehydes. The 2 : 4-dimethoxy-1 : 5-dialdehydo-benzene obtained from (I) melts at 215° (semicarbazone, m.p. 252°).

101. Syntheses of 2-benzyl-resorcin and 8-benzyl-4-methyl-umbelliferone.

S. B. Rajopadhye, Poona.

2-Benzoyl-resorcin, (Limaye, *Ber.*, 1934, **67**, 12), gave on reduction by Clemmensen method 2-benzyl-resorcin, (I), m.p. 85°, $C_{13}H_{12}O_2$. (I) formed its diacetate, m.p. 83°, dibenzoate, m.p. 136°, dimethyl ether, m.p. 54°. With acetoacetic ester (I) gave 8-benzyl-4-methyl-umbelliferone, (II), m.p. 238°, $C_{17}H_{14}O_3$, which was also obtained by the reduction of 8-benzoyl-4-methyl-umbelliferone, (*cf.*, S. D. Limaye and D. B. Limaye, Supplement to *Rasayanam*, 1938, **1**, 1–4). (II) regenerated (I) on hydrolysis with sodium hydroxide. (II) gave an acetate, m.p. 156°; benzoate, m.p. 146°; and methyl ether, m.p. 141°.

102. Studies on the formation of the Grignard reagent.

S. H. Zaheer *and* C. L. Mehrotra, Lucknow.

In our last paper we have mentioned the non-formation of the magnesium compound in case of iodo-nitro (amino or acetanildo) diphenyls and this led us to attempt a study of the influence of the second substituent over the formation of the magnesium compounds of mono-halogen derivatives of benzene and of diphenyl. Gilman (*J.A.C.S.*, 1923, **45**, 150 and 159; 1923, **45**, 2462) has estimated the yields of different aromatic halides but extensive search could not give us any literature on the formation of the magnesium compound with nitro, amino aromatic halides. We, therefore, attempted to make a quantitative estimation of the yields of magnesium derivatives formed from different compounds.

The method of estimation consisted in starting with the preparation of the magnesium compound of the type RMgX, hydrolyzing it with water and estimating the amount of Mg(OH)X thus formed by treating it with a known excess of acid which was back titrated. From this the percentage yield of magnesium compound formed was calculated.

Two important facts were noted during the interaction of magnesium and aromatic halides. Firstly, the amount of ether has got a definite influence on the formation of magnesium compound and should be in the ratio of 4 or 5 volumes of ether to one volume of the halide, and, secondly, the amount of iodine used as catalyst should be very small.

From the results obtained it was found that the yield of Grignard's reagent was maximum in iodo-benzene, less in bromo- and very little in chloro-benzene. Similar results were obtained with *di*-halogen derivatives, the yield increasing from *di*-chloro to *di*-bromo-benzene.

But with the introduction of the nitro group as the second substituent the interaction totally stops and the yield is nil. Also the phenyl group has probably a retarding influence over the yield of magnesium compound since it has been observed that iodo-benzene gives a larger yield than iodo-diphenyl. CH_3 group does not interfere with the formation of the magnesium complex as determined by Gilman. (Bromo-benzene 90·6%, iodo-benzene 95·8%, chloro-benzene ·875%, *m*-dibromo-benzene 83·65%, dichloro-benzene 1·94%, *o*-iodo-diphenyl 70·4%, and nil in cases of *p*-nitro-chloro-benzene, *p*-nitro-bromo-benzene, dinitro-chloro-benzene, nitro iodo diphenyl, *o*-iodo-nitro-benzene, and *p*-bromo toluene 88·16%.)

Further work is being done on the formation of the Grignard's reagent by the action of magnesium and substituted aromatic halides.

103. Imido gold compounds.*

A. TYABJI, Bombay.

Certain auric imido compounds can be prepared by mixing warm aqueous solutions of $KAuBr_4$ or a similar salt with an imide together with the equivalent of KOH or the potassium derivative of the imide. The substances prepared from phthalimide or saccharin were of the type $M[AuX_2(imido)_2]$ ($X = Br$ or Cl) and from succinimide of the type $M[AuX(imido)_3]$. No salt of the type $M[Au(imido)_4]$, as claimed by Kharash and Isbell, could be isolated. These halogen derivatives undergo hydrolysis in aqueous solution with the production of the free acid and, in some cases, accompanied by a further change. For instance, the phthalimido compound $K[Au(C_8H_4O_2N_2)Br_2]$ is hydrolyzed to diphthalimido-dihydroxy-auric acid $H[Au(C_8H_4O_2N_2)(OH)_2]$ and potassium di-*o*-benzoicsulphinimido-dibromoaurate undergoes the following change:—

$$3K[Au(imido)_2(Br)_2]+2H_2O = 3K^+ + 2H^+ + 2Br^- + 2[Au(imido)_3(OH)]^- + [AuBr_4]^-.$$

Some interest may be attached to sodium di-*o*-benzoicsulphinimido-dichloroaurate, which was found to form extremely stable yellow gels in aqueous solution. All the compounds described decompose at temperatures above 200° and are rapidly reduced when treated in hot water with $SnCl_2$ or SO_2.

104. Gold co-ordination compounds with thioethers.*

A. TYABJI, Bombay.

An attempt has been made to throw light on the varying affinity of gold to sulphur in organic sulphides. It has also been possible to prepare aurous compounds in a very pure state by using solutions of bromoaurous acid $HAuBr_2$ which is easily made by treating solutions of $KAuBr_4$ in aqueous alcohol with SO_2 until the solution is decolourized.

Whereas dibenzyl sulphide easily co-ordinates with halogeno-gold compounds to form aurous and auric derivatives, neither diphthalimido-diethyl-sulphide, diamino-diethyl-sulphide nor its halogen acid salts co-ordinate with gold. Diphthalimido-diethyl-sulphide and dibenzyl-disulphide are merely oxidized by $KAuBr_4$ to the corresponding sulphozides. The halogen salts of diamino-diethyl-sulphide form compounds of the type $NH_3XC_2H_4SC_2H_4NH_3AuX_4$, and the free base, in contrast with ethylene diamine, forms totally insoluble compounds which could not be purified by crystallization and whose behaviour may be explained by the formula

$$XAu \leftarrow NH_2C_2H_4SC_2H_4NH_3AuX_4.$$

Bromoaurous acid reacts with dibenzylsulphide in alcohol to afford the dimorphous dibenzylsulphido-bromogold (I). This reacts with one atom of bromine to afford the reddish brown dibenzylsulphido-dibromogold (II), with two atoms of bromine to the red dibenzylsulphido-tribromogold (III) and with one atom of iodine to the dark, highly refractive compound dibenzylsulphido-bromoiodogold (IV). (II), (III), and (IV) are reconverted to (I) by warming in alcohol and (II) affords (III) on treatment with bromine. All these compounds appear to be non-ionic by their solubility in organic solvents and insolubility in water. Special interest attaches to (II) and its chloro-anologue, which were found by the cryoscopic method

* The work has been done in Prof. C. S. Gibson's Laboratory, in the University of London.

in bromoform to be monomolecular, whereas, in order to have the required effective atomic number 34, these substances should be bimolecular. Crystallographic studies of the problem are being undertaken at Oxford.

105. Reactivity of 5-substituted resorcinol derivatives. Part I. The condensation of α-resorcylic acid and its ethyl ester with ethyl acetoacetate and malic acid.

(MISS) K. D. GAVANKAR *and* R. C. SHAH, Bombay.

Orcinol (5-methyl resorcinol) behaves, as is well known, abnormally in some substitution and condensation reactions, the reactivity in some cases, being in the usual 4 position and in others, in the 2-position, e.g. Pechmann condensation with β-ketonic esters gives 5-hydroxy coumarin derivatives while condensation with malic acid gives the 7-hydroxy coumarin derivative. Further Kostanecki acytylation of orcacetophenone proceeds abnormally giving a 4-acetyl coumarin instead of the expected chromone (Sethna and Shah, *J. Indian Chem. Soc.*, 1940, **17**, 239). Sethna and Shah have attributed this abnormality to the steric effect of the 5-methyl substituent. In the present work, the condensation of α-resorcylic acid with ethylacetoacetate and malic acid, and of ethyl α-resorcylate with ethylacetoacetate has been studied. The products have been proved to have the constitutions of 7-hydroxy-2-methyl chromone-5-carboxylic acid, 5-hydroxy-coumarin-7-carboxylic acid, and methyl 5-hydroxy-4-methyl-coumarin-7-carboxylate, respectively as on hydrolysis and decarboxylation they give 7-hydroxy-2-methyl chromone, 5-hydroxy-coumarin, and 4-methyl-5-hydroxy-coumarin, respectively.

The results, therefore, support the view of Sethna and Shah (*loc. cit.*) that the 5-substituent has a profound influence probably due to steric effect on the reactions of resorcinol derivatives.

106. Aluminium chloride—a new reagent for the condensation of β-ketonic esters with phenols. Part VII. The condensation of 4-nitroresorcinol with ethyl acetoacetate.

N. B. PAREKH *and* R. C. SHAH, Bombay.

The condensation of 4-nitroresorcinol with ethyl acetoacetate in the presence of sulphuric acid gives 4-methyl-6-nitro-7-hydroxy-coumarin (Chakravarti and Banerjee, *J. Indian Chem. Soc.*, 1937, **14**, 37). The condensation in the presence of anhydrous aluminium chloride, which has now been successfully carried out gives a different product, which is shown to be 4-methyl-5 hydroxy-6-nitro-coumarin. The formation of the 5-hydroxy-coumarin derivative shows for the first time that in 4-nitro resorcinol, the chelation of the 4-nitro group with the ortho-hydroxyl group stabilizes one of the Kekule forms by fixation of the double bond. Baker and Lothian (*J.C.S.*, 1936, 276) investigated the thermal rearrangement of the 1-*o*-allyl-ether of 4-nitroresorcinol in order to ascertain whether one of the Kekule forms is stabilized in 4-nitroresorcinol, but could not obtain any definite result.

107. The benzoylation of 5-hydroxy-6-acyl-coumarins in presence of pyridine.

C. V. DELIWALA, N. M. SHAH, Ahmedabad, *and* R. C. SHAH, Bombay.

During attempts to benzoylate 5-hydroxy-6-acyl-coumarin derivatives by means of benzoyl chloride in pyridine solution, the expected *o*-benzoyl derivatives were not obtained.

Instead of the expected 5-*o*-benzoyl derivative, 5-hydroxy-6-acetyl-4-methylcoumarin (Sethna, Shah, and Shah, *J.C.S.*, 1938, 228) on treatment

with benzoyl chloride in its pyridine solution gave 4-methyl-flavono-7′ : 8′ : 6 : 5-α-pyrone, whose constitution has been proved by its unambiguous synthesis from 4-methyl-5-hydroxycoumarino-6-phenyl-styryl ketone (*Proc. Ind. Sci. Cong.*, 1940, Abs., page 61) by selenium dioxide reaction. 5-Hydroxy-6-propionyl-4-methylcoumarin on similar treatment with benzoyl chloride gave 4-methyl-3′-benzomethyl-flavono-7′ : 8′ : 6 : 5-α-pyrone and 4-methylcoumarino-5-*o*-benzoyl-6-dibenzoyl-ethane. 5-Hydroxy-6-butyryl-4-methylcoumarin on similar treatment gave 4-methylcoumarino-5-*o*-benzoyl-6-dibenzol-propane. It appears that *o*-benzoyl derivative initially formed undergoes rearrangement accompanied by the elimination of water molecule to give directly the flavone. This change is analogous to that undergone by *o*-benzoyl-acetophenones in presence of K_2CO_3(Baker, *J.C.S.*, 1933, 1381). Recently pulverized sodium has been used in such transformations by Virkar and Wheeler (*J.C.S.*, 1939, 1679). In the reactions described here the pyridine plays the same part as K_2CO_3, Na and similar substances (Venkatraman and others, *Curr. Sci.*, 1933, 214; *J.C.S.*, 1936, 1767).

108. Hetero-cyclic compounds: Chalkones derived from 5-hydroxy-6-acetyl-4-methylcoumarin.

C. V. DELIWALA *and* N. M. SHAH, Ahmedabad.

5-Hydroxy-6-acetyl-4-methylcoumarin on condensation with benzaldehyde in presence of caustic potash gave 4-methyl-5-hydroxycoumarino-6-phenyl-styryl ketone (*Proc. Ind. Sci. Cong.*, 1940, Abs., page 61). With a view to prepare various coumarino-flavones, this reaction has been extended to several aldehydes. Vanillin, protocatechuic aldehyde, β-resorcylaldehyde, etc., have been condensed and the corresponding chalkones prepared. The action of selenium dioxide on these coumarino-chalkones has been studied in some cases and the coumarino-flavones synthesized. Attempts to prepare the coumarino-flavonones are in progress.

109. Synthesis of coumarins from *o*-hydroxy-aryl alkyl ketones. Part IV.

D. CHAKRAVARTI, Calcutta.

In continuation of the previous work (Chakravarti and Majumdar, *J. Indian Chem. Soc.*, 1938, **15**, 136; 1939, **16**, 389; Chakravarti and Datta, *ibid.*, 1940, **17**, 65) 1-acetyl-2-naphthol and 1-propionyl-2-naphthol methyl ethers have been condensed with ethyl bromo-acetate and ethyl α-bromopropionate and the unsaturated esters, thus obtained, have been converted to coumarin derivatives by heating with hydriodic acid.

110. Effect of methylation on the hydrolysis of 6-ethyl-4-methyl-umbelliferone.

S. V. PARANJPE, Poona.

Elimination of the α-pyrone ring in 6-ethyl-4-methyl-umbelliferone (I), during alkali hydrolysis was observed by S. D. Limaye (Ph.D. Thesis Univ. of Bombay, 1940; *cf.*, *Proc. Ind. Sci. Congress*, 1939, II, 105). Methy ether of (I), $C_{13}H_{14}O_3$, m.p. 163°, (II), gave on hydrolysis with NaOH solution 2-hydroxy-4-methoxy-5-ethyl-β-methyl-cinnamic acid, $C_{13}H_{16}O_4$, m.p. 104° (decomp.) (III) by the opening of the α-pyrone ring. (III) on treatment with conc. H_2SO_4 or sodium bicarbonate solution, suffers ring closure regenerating (II). (III) loses CO_2 even at ordinary temperature forming a sticky product. Methyl ether of (III), $C_{14}H_{18}O_4$, m.p. 159°.

Thus the effect of methylation on the hydrolysis of (I) is that ring opening takes place.

111. Effect of butylation on the hydrolysis of 8-acetyl-4-methyl-umbelliferone.

N. K. Shiralkar, Poona.

8-Acetyl-4-methyl-umbelliferone, (Limaye, *Ber.*, 1932, **65**, 375), gave with *n*-butyl bromide, its butyl ether, (I) m.p. 98°, $C_{16}H_{18}O_4$. (I) on hydrolysis with *N* NaOH (10 mols.) yielded *cis*-2-hydroxy-4-acetyl-4-butoxy-β-methyl-cinnamic acid, (II), m.p. 131° (decomp.), $C_{16}H_{20}O_5$, which readily lost a molecule of water regenerating (I). Methyl ether of (II), m.p. 91°, $C_{17}H_{22}O_5$, (III).

Hydrolysis of (I) with 0·25 *N* NaOH (7 mols.), as also with *N* NaOH in the presence of yellow HgO, gave *trans*-2-hydroxy-3-acetyl-4-butoxy-β-methyl-cinnamic acid, (IV), m.p. 147° (decomp.), isomeric with (II) $C_{16}H_{20}O_5$, but which readily lost CO_2. Methyl ether of (IV), m.p. 131°, $C_{17}H_{22}O_5$, (V). Under the action of sunlight (III) was converted into (V).

Thus the effect of butylation on the hydrolysis of 8-acetyl-4-methyl-umbelliferone, is similar to that of methylation, observed by Limaye and Sathe (*Rasayanam*, 1936, **1**, 30).

112. Synthesis of 8-ethyl-7-hydroxy-2-methyl-chromone.

S. D. Limaye *and* R. D. Sapre, Poona.

2-Ethyl-4-acetyl-resorcin, (I) (S. D. Limaye and D. B. Limaye, *Rasayanam*, 1937, **1**, 101), gave on condensation with fused sodium acetate and acetic anhydride, an oily product which on hydrolysis with ammonia yielded 8-ethyl-7-hydroxy-3-acetyl-2-methyl-chromone, $C_{14}H_{14}O_4$, m.p. 160–165°, (II). (II) on hydrolysis with NaOH formed 8-ethyl-7-hydroxy-2-methyl-chromone, $C_{12}H_{12}O_3$, m.p. 201°, (III). Methyl ether of (III), m.p. 130°, condensed with benzaldehyde in the presence of sodium ethoxide to give a styrene derivative, $C_{20}H_{18}O_3$, m.p. 200°, thus confirming the chromone constitution of (III). (III) on further hydrolysis regenerated (I).

The action of anhydrous aluminium chloride on the acetates of (II) and (III) is being studied.

113. Synthesis of furo-chromones from hydroxy-chromones.

Govind Ramachandra Kelkar, Poona.

Starting with a hydroxy-coumarone, 3-2′-dimethyl-5′-6′-furo-chromone has already been synthesized by Limaye and Sathe (*Rasayanam*, 1937, **1**, 87). Furo-chromones have now been synthesized by starting from hydroxy-chromones. 7-Acetoxy-2 : 3-dimethyl-chromone (Wittig and Richter, *Ber.*, 1926, **59B**, 116) gave 7-hydroxy-8-acetyl-2 : 3-dimethyl-chromone, (I), $C_{13}H_{12}O_4$, m.p. 215°. (I) on condensation with brom-acetic ester gave 7-(carbothoxy-methoxy)-8-acetyl-2 : 3-dimethyl-chromone, $C_{17}H_{18}O_6$, m.p. 139°, which on hydrolysis yielded 7-(carboxy-methoxy)-8-acetyl-2 : 3-dimethyl-chromone, (II), $C_{15}H_{14}O_6$, m.p. 240° (decomp.). (II) on heating alone or with sodium acetate and acetic anhydride gave 3-2′-3′-tri-methyl-7′-8′-furo-chromone $C_{14}H_{12}O_3$, m.p. 245°.

Similarly, 7-(carboxy-methoxy)-8-acetyl-2-methyl-chromone, $C_{14}H_{12}O_6$, m.p. 275° (decomp.) and 3-2′-dimethyl-7′-8′-furo-chromone, $C_{13}H_{10}O_3$, m.p. 195°; 7-(carboxy-methoxy)-8(6?)-benzoyl-2 : 3-dimethyl-chromone, $C_{20}H_{16}O_6$, m.p. 225° (decomp.) and 3-phenyl-2′-3′-dimethyl-7′-8′(6′?)-furo-chromone, $C_{19}H_{14}O_3$, m.p. 155° ; and 7-(carboxy-methoxy)-8(6?)-benzoyl-2-methyl-chromone, $C_{19}H_{14}O_6$, m.p. 260° (decomp.) and 3-phenyl-2′-methyl-7′-8′(6′?)-furo-chromone, $C_{18}H_{12}O_3$, m.p. 193°, have also been synthesized.

114. A third method for the synthesis of 6 : 8-diethyl-4-methyl-umbelliferone.

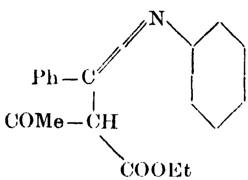
SHRIDHAR DATTATRAYA LIMAYE, Poona.

In keeping with the behaviour of 4-acyl-resorcins, (*cf.*, *Rasayanam*, 1937, **1**, 101), 2-ethyl-4-acetyl-resorcin did not condense with acetoacetic ester in the presence of concentrated sulphuric acid. However, with phosphorus oxychloride as the condensing agent, was obtained 6-acetyl-8-ethyl-4-methyl-umbelliferone, (Limaye and Miss Ghate, *Rasayanam*, 1939, **1**, 169), which on Clemmensen reduction gave 6 : 8-diethyl-4-methyl-umbelliferone, m.p. 137°, already synthesized in other ways (S. D. Limaye and D. B. Limaye, *Rasayanam*, 1937, **1**, 110; *Proc. Ind. Sci. Congress*, 1939, **II**, 105).

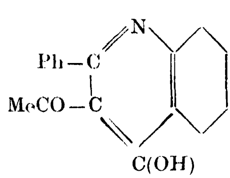
115. Imido-chlorides. Part VII. Condensation of anilide-imido-chlorides with ethyl sodio-acetoacetate: Synthesis of 2-phenyl-4-hydroxy-3-acetyl-quinolines.

N. V. LIMAYE *and* R. C. SHAH, Bombay.

Benzanilide imido-chloride on condensation with ethyl sodio-acetoacetate affords ethyl phenylimino benzyl-acetoacetate (I) which is cyclized by heat to 2-phenyl-4-hydroxy-3-acetyl quinoline (II) whose constitution has been established. A number of other substituted benzanilide imidochlorides have been similarly condensed and a number of 2-phenyl-4-hydroxy-3-acetyl quinoline synthesized in good yields.



(I)



(II)

116. An isomer of 2 : 6-dimethyl-4-ethyl-pyridine.

R. H. SIDDIQUI, Aligarh.

The author was busy with a new synthesis of 2-methyl-4-ethyl-pyridine and for obtaining it he prepared 2 : 6-dimethyl-4-ethyl-pyridine. During this working under certain conditions he isolated a base which from the analytical data and from the values obtained for the hydrochloride, chloroplatinate and aurichloride appears to be an isomer of 2 : 6-dimethyl-4-ethyl-pyridine. All the salts are crystalline with definite melting points.

117. Acridine derivatives. Part VI.

S. J. DAS-GUPTA, Baranagore (Calcutta).

In continuation of previous work (Das-Gupta, *Jour. Indian Chem. Soc.*, 1940, **17**, 244) various metallic (gold, silver, antimony, copper and mercury) compounds of 5-thiol acridine and its other derivatives have been prepared. It is being noted that 5-thiol acridine itself is less acidic than its any other derivatives. The mercury and antimony salts are

being found to exist in allotropic modifications. The auro- and mercuro-derivatives are being pharmacologically tested for finding out their anti-bacterial properties.

118. Acridine derivatives. Part VII.

S. J. DAS-GUPTA, Baranagore (Calcutta).

In a previous work (Das-Gupta, *Jour. Indian Chem. Soc.*, 1939, **16**, 364) certain sulphonamide phenyl sulphonamido-acridine derivatives have been prepared. In the present investigation simple sulphanilamide derivatives of acridines, of the type $NH_2C_6H_4SO_2NH.R$ as well as $R.NH.C_6H_4SO_2NH_2$, where R is a 7-methoxy acridine derivative, have been described. The pharmacological characteristics of these compounds are being studied.

119. Heterocyclic compounds. Part XVII. Some chemical properties of S-alkyl ethers of 1-mercapto-benzoxazole.

R. D. DESAI *and* S. V. NABAR, Bombay.

The methyl, ethyl, propyl, butyl, and benzyl ethers of 1-mercapto-benzoxazole have been prepared and it is observed that they are transformed into *n*-alkyl derivatives of thio-1 : 2-dihydrobenzoxazolone by heating them in presence of traces of iodine. This method furnishes a simple method of preparing these compounds, and provides an example of the conversion of R-S-C=N- into S=C-N-R. The various S-alkyl ethers of 1-mercapto-benzoxazole have been converted into quaternary ammonium compounds by the action of alkyl iodides, and the action of dilute solution of alkali and sodium hydrosulphide has been studied. The first reaction gave the *n*-alkyl derivatives of 1 : 2-dihydro-benzoxazolone, while the second reaction gave the *n*-alkyl derivatives of 1 : 2-dihydro-thiobenzoxazolone.

120. Heterocyclic componds. Part XVIII. Coumarins from 4-ethyl-2-acetylresorcinol and 5-methyl-2-acetylresorcinol.

R. D. DESAI, C. K. MAVANI, *and* (MISS) V. M. VAKIL, Bombay.

As a continuation of our work on the effect of substituents on the resorcinol nucleus in the formation of coumarins, we have condensed 4-ethyl-2-acetylresorcinol and 5-methyl-2-acetylresorcinol (*iso*-orcaceto-phenone) with acetoacetic ester and its C-alkyl derivatives. The first dihydroxyketone gave the coumarins with great readiness by the Pechmann method, though the yields diminished with the C-alkyl-acetoacetic ester. It thus resembled 2-acetyl resorcinol in its behaviour (Limaye, *Rasayanam*, 1936, **1**, 65; Shah and Jatty, *Science Congress Abs.*, 1940, **III**, p. 65) and differed considerably from its isomer 4-acetyl-6-ethylresorcinol which undergoes this reaction only in the presence of phosphoryl chloride (Desai and Ekhlas, *Proc. Ind. Acad. Sci.* (A), 1938, **8**, 200) or anhydrous aluminium chloride (Sethna, Shah, and Shah, *J.C.S.*, 1938, 228).

Iso-orcacetophenone underwent deacetylation, and gave only 5-hydroxy-4 : 7-dimethylcoumarin with aceto-acetic ester. Its behaviour in this respect is surprising as the isomeric β-orcacetophenone has been shown to undergo the coumarin condensation with aceto-acetic ester by Desai and Ekhlas (*loc. cit.*) as well as Sethna, Shah, and Shah (*loc. cit.*). These two hydroxy-ketones thus furnish an interesting example of the effect exerted by the same substituent in different positions.

121. Heterocyclic compounds. Part XIX. The synthesis of 5-alkylamino- and 5-arylamino-1 : 2 : 3 : 4-tetrahydro-acridines.

R. D. DESAI *and* V. M. SHINTRE, Bombay.

Bukhsh and Desai have described the synthesis of a few 1 : 2 : 3 : 4, tetrahydroacridones in part X of this series (*Proc. Ind. Acad. Sci.* (A) 1939, **10**, 262). These acridones have been now converted into 5-chloro-acridine derivatives which have been condensed with simple aliphatic as well as aromatic amines. We have also condensed the 5-chloro-derivatives with sulphanilamide and sulphanilanilide with the hope that these derivatives might furnish some useful antiseptics.

122. Attempted synthesis of phenanthrene derivatives.

R. D. DESAI *and* W. S. WARAVDEKAR, Bombay.

The compounds obtained by condensing resorcinol, pyrogallol, and α-naphthol with phenyl-acetic acid by the application of the Nancki reaction were subjected to dehydration, with the object of converting them into phenanthrene derivatives, but the attempts were unsuccessful. The keto-group was reduced, but the reduced products did not cyclize. We are continuing our attempts by introducing the activating groups, either in the phenol or the acid molecule.

123. Studies in the synthesis of phenanthrene derivatives: Limitations of Bradsher synthesis.

S. H. ZAHEER *and* C. L. MEHROTRA, Lucknow.

Bradsher synthesized 9,10-aryl phenanthrenes by condensing the magnesium compound of 2-iodo diphenyl with different aliphatic compounds as methoxy-aceto-nitrile, phenoxy acetones, etc., and we thought of applying this method to the preparation of other substituted phenanthrene derivatives, specially 2 and 3 chloro, nitro and amino phenanthrenes (which are not easily synthesized) starting from 4 and 5 substituted diphenyl derivatives.

The compounds chosen by us were 2-2′ di-iodo diphenyls 4-nitro 2′-iodo diphenyl, 4-amino-2′-iodo diphenyl and 4-acetanilido-2′-iodo diphenyl in order to prepare either a pyrene or a phenanthrene derivative from the first or to get 2-nitro, amino or acetanilido phenanthrenes from the others.

We were unable to confirm Mascarelli's work as our attempts to prepare 2-2′ di-iodo-diphenyl (Mascarelli, *J.C.S.*, *Abs.*, 1907, **1**, 1021) were not successful. The other compounds mentioned did not react with magnesium. We, therefore, conclude that Bradsher's synthesis is not applicable in the preparation of 2-nitro (amino)-phenanthrenes.

During the course of the above studies we were able to prepare a few new compounds of diphenyl, viz., 4-nitro-2′-iodo diphenyl, 4-amino 2′-iodo diphenyl, 4-acetanilido 2′-iodo diphenyl, the starting material in all cases being ortho amino diphenyl. This on acetylation gave 2-acetyl compound, which on nitration gave 4-nitro 2′-acetanilido-diphenyl, which further on hydrolysis gave 4-nitro 2′-amino-diphenyl. Either of these on diazotization and the decomposition of the diazo compound with potassium iodide solution yielded 4-nitro 2′-iodo diphenyl (m.p. 97°C.). The nitro group on reduction with tin and hydrochloric acid gives the amino compound, viz., 4 amino 2′-iodo-diphenyl (b.p. 240–250°C. at 12 mm. pressure). This on acetylation gave 4-acetanilido 2′-iodo-diphenyl (m.p. 155°C.).

The non-formation of the magnesium compound in the above cases led us to a study of the influence of the substituents in the formation of

magnesium compounds of the halogeno benzenes and diphenyls, an account of which is given in another paper.

124. On sulphanilamide derivatives possessing heterocyclic rings. Part I. Action of heterocyclic sulphonyl chlorides with aromatic and hetero-cyclic amines.

P. C. Guha *and* Debabrata Das-Gupta, Bangalore.

3 : 5-Dithiol-4 : 1 : 2-thiobiazole, 1-phenyl-3-thiol-5-thio-4 : 1 : 2-thiobiazole and 3-thio-5-amino-4 : 1 : 2-thiobiazole have been prepared and the first two converted into their corresponding sulphonyl chloride via sulphonic acids. They react with aromatic amines. The sulphonyl chlorides of the above-mentioned heterocyclic compounds are being reacted with different aromatic and heterocyclic amines with a view to finding out their therapeutic efficiency.

125. On sulphanilamide derivatives possessing heterocyclic rings. Part II. Action of *p*-acetamino-benzene sulphonyl chloride with heterocyclic amines.

P. C. Guha *and* Debabrata Das-Gupta, Bangalore.

The following amines (phenyl dithiobiazolonamino-phenyl-sulphide, phenyl dithiobiazolonamino-tolyl-sulphide, phenyl dithiobiazolonhydrosulphamin, iminodihydrothiobiazolthiol, diiminotetrahydrothiobiazol, 2-amino-thio-(bb_1)-biazole, 5-phenyl-2-aminothio-(bb_1)-biazole are prepared. Their action on *p*-acetaminobenzene sulphonyl chloride are being studied with a view to study their therapeutic efficiency.

126. On the preparation of sulphanilamide compounds possessing selenoheterocyclic rings.

P. C. Guha *and* A. N. Roy, Bangalore.

Selenium and its compounds are known to possess important therapeutic properties. With a view to studying the therapeutic effect of selenium in heterocyclic residues attached with sulphanilamide compounds, some aminoselenazoles and selenhydantoins have been made. Their condensation with *p*-acetamino-benzene-sulphochloride are being studied.

127. Studies on sulphonamides.

U. P. Basu *and* S. J. Das-Gupta, Baranagore (Calcutta).

In a previous work (De and Basu, *Indian Jour. Med. Res.*, 1938, **26**, 537) it was noticed that substitution of the amide hydrogen of *p*-amino benzene sulphonamide by quinoline ring increases the toxicity of the resulting product without exerting any enhancement of its therapeutic activity. But a similar substitution by pyridine (*cf.*, Whitby, *Lancet*, **I**, 1210) or a thiazole ring (Fosbinder and Walter, *J. Amer. Chem. Soc.*, 1939, **61**, 2032; Herrell and Brown, *Proc. Staff Meetings Mayo Clin.*, 1939, **14**, 753) has been found to widen the activity of sulphanilamide to a considerable extent.

Several derivatives of sulphanilamide have, in the mean time, been prepared in this laboratory by reacting pure 4-acetamino benzene sulphonyl chloride with various 2-amino thiazoles, and hydrolyzing the subsequent condensation products to the corresponding 2-sulphanilamido thiazoles. The general method of their preparation and the chemical characteristics of the compounds are being described.

128. Chemotherapy of bacterial infections. Part II. Selenium analogues of sulphonilamide compounds—diselenides, seleninic and selenonic acids.

P. L. NARASIMHA RAO, Bangalore.

In continuation of the first part of this series wherein some homologues of sulphonilamide derivatives have been described, the preparation of selenium analogues of sulphanilamide compounds has been undertaken with the hope that they may possess enhanced and more desirable anti-bacterial activity or throw further light upon the relation between chemical constitution and antibacterial action, just as the antimony and bismuth analogues of arsenical drugs offer advantages in combating protozoal diseases. Thus the preparation of some para-substituted diphenyldisalenides, selenides selenophenols, seleninic and selenonic acids have been described.

129. Chemotherapy of bacterial infections. Part III. N′-β-phenylethylsulphanilamides.

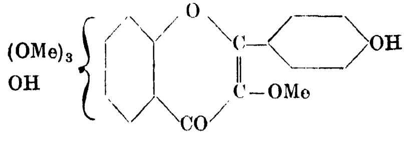
P. L. NARASIMHA RAO, Bangalore.

In order to find a suitable therapeutic agent for use in enteric bacterial injections, *p*-acetylaminobenzene sulphonyl chloride has been condensed with phenyl, *p*-methoxy-phenyl, *p*-nitrophenylethylamines and ac. tetrahydro β-naphthylamine and the resulting product hydrolyzed to the respective amines. Further work is in progress.

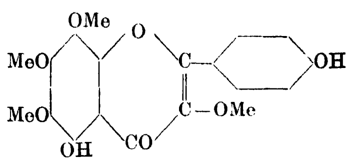
130. The constitution of calycopterin—the yellow colouring matter of the leaves of *Calycopteris floribunda*.

R. C. SHAH, K. VENKATRAMAN, *and* V. V. VIRKAR, Bombay.

The partial constitution (I) was previously assigned to *calycopteris*, isolated from the leaves of *Calcycopteris floribunda*; the positions of the three methoxy groups and one hydroxy group in the chromone nucleus were not determined (Ratnagirisevaram, Sehra, and Venkatraman, *Biochem. J.*, 1934, **28**, 1964). It is now found that *calycopteris* is a 5-hydroxy flavone derivative, as on methylation by diazomethane. Only one hydroxyl group (4′) gets methylated and the monomethyl *calycopteris*, characterized by the formation of acetyl and benzoyl derivatives, shows the characteristic properties of a 5-hydroxy flavone. As the hydroxyl group is thus shown to be in the 5 position, the three methoxy groups must be in positions 6, 7, 8. *Calycopteris* can now therefore be fully formulated as 5 : 5-dihydroxy-3 : 6 : 7 : 8-tetramethoxy flavone (II).



(I)



(II)

131. Constitution of soft-lac resin.

H. K. SEN, Ranchi.

Shellac is known to be composed of at least two distinct resins besides wax. The two are distinguished and readily separated by their solubilities in ether. The ether insoluble portion is called the pure resin and is the

more complex of the two. The ether soluble portion is called the soft resin and the following analytical data have been obtained from several specimens of soft resins from different samples of shellac.

Ultimate Analysis— C 73·2, H 1·2.
  Empirical formula—$C_{31}H_{56}O_5$.
Molecular weight—509–556.
  Molecular formula is $C_{31}H_{58}O_5$.
Unsaturation by hydrogen absorption—53–55.
  No. of ethylene linkage—1.
Acid Value—103–110.
  No. of carboxyl groups—1.
Saponification value—213·7.
  No. of ester or lactone linkage—1.
Saponification value of acetyl derivative—315·7.
Acid value of acetyl derivative—101·6.
(A.V. and S.V. of original sample of lac were 109·6 and 218·7 respectively.)
  No. of free hydroxyl—1.

Ultimate analysis of hydrolyzed soft resin gave the values C—70·9, H—10·98, $C_{31}H_{56}O_5+H_2O$, i.e. $C_{31}H_{58}O_6$ requires C—70·72, H—11·02.

The following provisional formula has therefore been formulated :

$$\begin{array}{lcr} CH{-}{-}\ (CH_2)_x{-}{-}{-}{-}{-}{-}{-}{-} & & CH{-}COOH \\ & & | \\ & & O \\ & & | \\ CH{-}{-}(CH_2)_y{-}{-}CH(OH) & {-}{-} & CO \end{array}$$

when $x+y = 25$

132. Natural coumarins from *Ferula alliacea*, Boiss.

P. K. Bose, Calcutta.

Three solid constituents have been isolated from the fruits of *F. alliacea*. One of these is *iso*pimpinellin. The second constituent has many points of similarity with byak-angelecin of Noguchi and Kawanami (*Ber.*, 1938, **72**, 344), although the specific rotation of the latter is half of that of the former. The third component, named ferulin, m.p. 87°, appears to be different from but isomeric with byakangelicol, m.p. 106°, of the Japanese authors, although both the compounds furnish apparently the same compound on hydrolysis. The probable constitution of ferulin is discussed.

133. Sterols from *Vernonia Anthelmintica* seeds.

N. L. Vidyarthi, Patna.

The sterol mixture from the non-saponifiable materials of the seeds of *Vernonia Anthelmintica* has been resolved into two fractions by phthalic anhydride. By the bromination of each fractions stigma sterol and sito sterols have been identified. There is also another sterol which melts at 142°C. and has its products different from the sterols known till now. The empirical formula for this sterol seems to be $C_{27}H_{50}O$. Further work on this sterol is in progress.

134. Studies in sterols. Part I. Oxidation of sterols.

P. L. Narasimha Rao, Bangalore.

It is known from the work of Lifschutz (*Ztschr. physiol. Chem.*, 1907, **50**, 436) and Bischoff (*Ztschr. ges. exp. Medizine*, 1936, **70**, 83), oxysterols

accompanying cholesterol and other sterols, are probably formed by autoxidation of the original compounds. The fact that oxidation of cholesterol esters with chromic acid gives rise to 7-oxy-compound (the first step in the synthesis of vitamin D from cholesterol; Windaus, (*Ann.*, 1935, **520**, 98) brought prominence to the question whether the so-called oxy-sterol is impure 7-oxy-compound from which the pro-vitamin D, 7-dehydrocholesterol, also accompanying cholesterol, may be formed, or whether it is entirely different. In this connection it is of interest to note that the autoxidation of unsaturated organic compounds, though usually follow the course taken by mild oxidative reagents especially selenium dioxide, often differs from the latter, e.g. in the case of α-pinene (*Annual Reports of Chem. Soc.*, London, 1937, p. 241). Thus Rosenheim and Starling (*J.C.S.*, 1937, 379) points out that cholesterol gives *cis*-5 : 6-cholestene-3 : 4-diol with selenium dioxide, while Cook isolated 7-oxy-cholesteryl acetate by autoxidation in presence of iron phthalocyanine. In order, therefore, to elucidate clearly the nature of all the oxy-sterols and possibly the mode of synthesis of the pro-vitamin D in Nature, different cholesterol esters as well as of some important phytosterols are subjected to oxidation under varied condition.

135. Active principles of fruits of *Zanthoxylum acanthopodium* DC.

K. N. BAGCHI *and* H. D. GANGULY, Calcutta.

Zanthoxylum acanthopodium DC grows in the Darjeeling hills at an elevation of 5,000 feet and upwards and attains the height of about 7 feet. The fruits locally known as 'Timboor' are taken in very small quantity for treatment of indigestion and intestinal griping. It is stated by them that if about half a dozen green fruits are taken, they may produce a choking sensation and even death.

The fruits, freshly collected, possess a sharp aromatic smell and produce when chewed an intense tingling and smarting sensation on the tongue and lips just as one gets with aconite root. An essential oil (yield about 2·3%) having an agreeable odour like that of eucalyptus oil was extracted from the green fruits but it was not found to be the cause of the characteristic tingling sensation produced by fresh fruits. A resinous substance (an oleo resin) with an unpleasant aromatic odour was also extracted after the separation of the essential oil and it was found to be the causative factor of the physiological effect stated above. No alkaloid nor any other active principle could be detected in the powdered fruits and seeds. Berberine, as stated to be the active principle of the bark (Kirtikar and Basu) was not found either. The other species of *Zanthoxylum*, viz.. *Z. budrunga* which grows to a much larger height, may be the species of *Zanthoxylum* in which berberine was found in the bark by the above authors. The fruits of *Z. budrunga* obtained from Darjeeling do not produce the characteristic tingling sensation on the tongue. The bark of this plant has not yet been procured for further investigation which is in progress.

136. Fixed oil from the seeds of *Salvia plebia*.

M. G. KELKAR, V. A. PATWARDHAN, *and* V. L. PRADHAN, Poona.

The plant, *Salvia plebia* (Labiatae), 'Kammorkasa', is common throughout India, and yields tiny, round, brownish-black seeds. On extraction of the well-crushed seeds with sulphuric ether, 20·5% of a pale yellow oil is obtained. It shows the following characteristics:—Sap. V. 188·5, Iodine V. (Winkler) 144·5, Acid V. 2·8, Refractive Index at 30°C. 1·482, Unsaponifiable matter 1·9%, Hexabromide V. 30·75% The mixed fatty acids gave 7·7% solid acids containing mainly stearic acid and 92·3% liquid acids containing

acid. Only a small quantity of linolic acid was obtained. The oil does not show good drying power. On heating with 1 p.c. cobalt linoleate at 230°C. for two hours, the oil is oxidized to a jelly. The oil heated with driers may be useful as a drying oil, especially in a mixture with other drying oils. Further examination of the oil is in progress.

137. The chemical relationships of botanically related seed oils. Part V. The occurrence of $C_{20}H_{40}O_2$ (Eicosanic acid) in the saturated fatty acids from *Adenanthera pavonisa* seed oil.

P. RAMASWAMI AYYAR *and* S. M. MAHDU MUHAMMAD, Bangalore.

The higher saturated fatty acids isolated by the potassium salt method outlined in part IV of this series (*Proc. Ind. Sci. Cong.*, 1940, III, No. 95, p. 79) were esterified with methyl alcohol and the resulting methyl esters subjected to fractional crystallization, successively, from a mixture of methyl alcohol and benzene, methyl alcohol and acetone, and finally, from methyl alcohol. The first fractions yielded pure methyl behenate (*ibid.*) and the final fractions yielded about two per cent of pure methyl eicosanate (m.p. 45-46°C., unchanged on mixing with a genuine specimen of pure methyl eicosanate the identity of which has been checked against a pure synthetic preparation of the ester).

138. On the constitution of santalbic acid.

B. L. MANJUNATH *and* S. SIDDAPPA, Bangalore.

The paper deals with the constitution of Santalbic acid isolated by Manjunath and Madhuranath from the oil of the seeds of *Santalum album* (*J. Ind. Chem. Soc.*, 1938, **15**, 389–392). The results show that it is an isomer of linoleic acid. The paper contains details of the investigation.

139. The chemical examination of the stem of *Tinospora cordifolia* (Miers).

H. SUBBA JOIS, Bangalore.

Three crystalline materials melting at 75–77°, 83-84° and 181° respectively have been isolated from the stem of the plant *Tinospora cordifolia* (*cf.*, Bhagwat and Bhide, *Proc. Ind. Sci. Congress*, 1934, 240). The substance melting at 83-84° is a monohydroxy alcohol of the fatty series and the substance melting at 181° has been found to have the molecular formula $C_{16}H_{18}O_5$. The chemical nature of these substances is under investigation.

140. Chemical examination of the fleshy aril of *C. paniculatus*.

R. H. SIDDIQUI, Aligarh.

Celastrus paniculatus grows throughout the hilly districts of India, Burma and Ceylon. The seeds are cinnamon brown and are completely enveloped in scarlet fleshy aril. This scarlet aril was examined chemically and yielded saturated, unsaturated fatty acids, benzoic acid, a scarlet viscous colouring matter and a sterol, m.p. 184·5° (Acetyl deriv. had m.p. 231°). It is of interest that from the seeds a different phytosterol is obtained, m.p. 136; Acetyl deriv., m.p. 119°, by Kumarswamy and Manjunath (*J. Indian Chem. Soc.*, 357, 1936).

141. Chemical examination of the roots of *T. montana.*

R. H. SIDDIQUI, Aligarh.

The plant is much cultivated in gardens throughout India and the root of the plant relieves toothache, kills intestinal worms and with lime juice it removes opacities of the cornea. From the alcoholic extract resins, a mixture of alkaloids and the following non-basic products are isolated. Alkaloidal fraction is under investigation.

Non-basic products.

(A) $C_{34}H_{56}O_4$—m.p. 250°.
(B) $C_{34}H_{56}O_2$—m.p. 230°.
(C) $C_{32}H_{52}O_2$—m.p. 210°.
(D) $C_{34}H_{56}O_2$—m.p. 165°.

142. Influence of formaldehyde on the reaction of mercuric chloride with wool.

G. T. GURSAHANI *and* C. S. NARWANI, Karachi.

Action of $HgCl_2$ on the formaldehyde-treated wool has been studied at various concentrations and compared with that on the untreated wool. The adsorbed Hg ions are exchanged by treating with NaCl and the remaining Hg is assumed to be combined. It is found that more quantity of $HgCl_2$ reacts with wool treated with formaldehyde. From the concentration curve there seem to be two kinds of reactions, both being of the same nature at 35°C. as well as 100°C.

It is concluded that (1) NH_2 group is absent in wool and (2) the formaldehyde reacts with wool in such a manner that both -NH- (peptide linkage group) and disulphide bonds are easily attackable by $HgCl_2$.

143. Dihydroquinamine and derivatives.

B. K. NANDI, Bombay.

Dihydroquinamine has been nitrated and then reduced to the amine. The amino group has then been condensed with bromoethyl phthalimide, bromo propyl phthalimide and 2-methoxy-6 : 6-dichloro acridine to convert the dihydroquinamine into various side chain and heterocyclic derivatives. These modifications into the quinine molecule have been introduced with a view to enhance the specific anti-malarial property of quinine. Experiments on monkey malaria are still awaiting.

144. Condensation between dinitroveratrole and amines.

B. K. NANDI, Bombay.

Dinitroveratrole reacts promptly with various amines and diamines. During the reaction either a nitro group or a methoxyl group of the dinitroveratrole is replaced by the amine, depending on the condition of reaction. Various derivatives with diethylamine, aniline, ortho-toluidine and para-toluidine have been prepared. The compounds are highly coloured with very low toxicity as has been found by experiments on dogs. Experiments are being made to employ them as suitable hair dyes on the line of the condensation products of phenols with amines.

145. Sulphonamide derivatives of guaiacol.

B. K. NANDI, Bombay.

Guaiacol, when treated with chlorosulphonic acid, gives a colourless, pasty sulphochloride derivative. On reaction with 10% ammonia the

sulphonamide derivative of guaiacol has been made. Also on reaction with α-amino pyridine and α-amino thiazole the respective guaiacol sulphonamido pyridine and guaiacol sulphonamido thiazole have been made.

These compounds are at present being examined against streptococcus and pneumococcus infections.

Industrial Chemistry

146. Synthesis of atebrin.

B. K. NANDI, Bombay.

Synthesis of atebrin has been accomplished in three parts, viz. (1) synthesis of 2-methoxy-6 : 9-dichloro acridine (acridine nucleus), (2) synthesis of 1-diethylamino-4-amino pentane (side chain), and (3) condensation of (1) and (2). Starting material for the first synthesis can be either *m*-tolylene diamine or toluene which can be chlorinated directly. The yields at every stage are fairly good except in one stage of condensation with para-anisidine by Gattermann's reaction.

The starting material for the synthesis of the side chain has been ethyl acetoacetate and the recently published method of Knunyantz *et al* has been utilized with advantage for isolation of the intermediate product acetopropyl alcohol. The synthesis of the diamine is a matter of considerable difficulty and deception, sometimes resulting in a very poor yield unless all the intermediate products are scrupulously checked for proper purity. Considerable modifications have been introduced in several stages of the entire synthesis.

The final synthesis of atebrin, i.e. the condensation of the nucleus with the side chain is effected easily in phenol medium resulting in very satisfactory yield.

The cost of manufacture on a semi-commercial scale has been calculated, on the basis of laboratory yields, and found to be easily competitive with the foreign make.

The drug has undergone all toxicity and pharmacological tests on animals and has finally been administered to human malaria with identical results as in the case of Bayer's atebrin.

147. Reduction of sodium oleate to sodium stearate.

M. GOSWAMI *and* P. BHADURI, Calcutta.

Sodium oleate has been almost quantitatively converted into sodium stearate at ordinary temperature and pressure by means of a specially prepared nickel and hydrogen. Further work on the industrial possibility of the process is being carried out.

148. Splitting of oils and fats by acid tar from petroleum refining.

M. GOSWAMI *and* K. BASAK, Calcutta.

Acid tar obtained in the process of refining petroleum has been successfully used in catalytically hydrolyzing fats and oils.

149. Physical and chemical constants of Gujarat ghee.

B. N. MEHTA, Baroda.

A detailed investigation of the physical and chemical constants of a large number of samples of ghee from North and Central Gujarat

(Bombay Presidency) has been made. It has been shown that there is a very small variation in the R.M. and B.R. values at 40°C. from month to month. The variation is, however, very small or even negligible and further that an examination of the different figures shows that there is no effect of season on the constants. The constants of samples from North Gujarat and Central Gujarat have nearly the same value and ghee from these areas seem to be quite similar.

150. Distillation of Indian vegetable oils under reduced pressure. Part I. Niger seed oil.

Y. V. DUVEDI, N. L. PHALNIKAR, *and* B. V. BHIDE, Poona.

Niger seed oil has been distilled at a pressure of 15 mm. The products of distillation are: (1) thick viscous residue, and (2) a distillate consisting of (*a*) a neutral portion (mainly unsaturated hydrocarbons), (*b*) saturated acids consisting of myristic, palmitic and stearic acids, and (*c*) saturated and unsaturated liquid acids. The saturated liquid acids were capric and caprylic acids and the unsaturated acid was oleic acid. No linolic acid (one of the constituents of the oil) was found in the distillate. During the distillation considerable amount of acrolein was evolved. In the distillate, no other aldehyde or ketone was detected. The composition of the thick residue is under investigation.

151. The action of sulphur on fatty oils. Part I. Reaction with linseed, cotton seed and castor oils.

R. D. DESAI *and* R. C. SHAH, Bombay.

We have undertaken a systematic study of the interaction of sulphur with fatty oils, and examined the linseed, cotton seed and castor oils in this respect. The amount of the chemical reaction undergone during the course of the variation of temperature and sulphur has been followed by determining their saponification and iodine values which have been observed to increase regularly with the intake of sulphur. In the case of castor oil some irregularity was observed and it was suspected that this might be due to the disturbing effect of the hydroxyl group of the recinoleic acid. Therefore, we have tried to study the action of dehydrating agents, under various conditions of temperature and pressure, not only on the oil, but its alkyl esters and anilides.

152. Continuous hydrogenation of oils.

R. V. JOGLEKAR *and* S. K. K. JATKAR, Bangalore.

The comparative activities of different percentages of nickel catalyst in the continuous hydrogenation of oils have been studied. It has been found that the activity increases with concentration to a maximum at 15 per cent concentration, after which it decreases until the minimum is reached at 50 per cent nickel, and then the activity increases with concentrations, that of the unsupported catalyst being found to be highest.

153. Hydrogenation of sesame oil by the continuous process.

R. V. JOGLEKAR *and* S. K. K. JATKAR, Bangalore.

Sesame oil was hydrogenated by the nickel carbonate kieselguhr catalyst. A study of the selective hydrogenation of the component glycerides indicated that saturated glycerides were formed long before the linolein percentage dropped below ten. It appears that the hydrogenation by the continuous process is less selective than by the batch process.

154. Dispersion of ghee mixed with cocoanut oil.

R. V. JOGLEKAR *and* S. K. K. JATKAR, Bangalore.

The refractive indices and dispersions of the samples of ghee mixed with cocoanut oil in different proportions were measured on a Pulfrich refractometer at 40°C. for the mercury green and violet lines. The results show that on mixing ghee with cocoanut oil the change observed in dispersion is comparatively much greater than the change in the refractive index.

155. Alcoholysis and hydrolysis of oils and fats.

K. N. RAHALKAR *and* S. K. K. JATKAR, Bangalore.

Addition of 5 to 10 per cent cocoanut oil to groundnut oil increased the degree of hydrolysis by lime and magnesia, from 76% to 91–99% under similar conditions.

The alcoholysis of oils and fats by methyl and ethyl alcohol in presence of acid and alkali catalysts has been investigated with a view to study the kinetics of the reaction and to explore the possibility of manufacturing glycerine and esters of fatty acids, using power alcohol.

156. Recovery of glycerine from soap-lye.

P. C. GUHA *and* AJOY GUPTA, Bangalore.

In continuation of the preliminary work described in last year's Science Congress Abstracts (*Proceedings*, p. 105), the 80 per cent crude glycerine on being distilled with superheated steam at 180°, gave pure glycerine 70 per cent strength, which was decolorised and concentrated to 98 per cent under vacuum.

The laboratory scale experiment has been reproduced on a semi-commerical scale with a plant made in the department yielding about 100 lbs. of 70 per cent distilled glycerol per day, which, after animal charcoal treatment, has been concentrated to 98 per cent glycerine, corresponding to pale straw colour dynamite grade glycerine. Some chemically pure glycerine has also been made.

157. The chemical examination of the pulp and kernels of the Palmyra palm (Lat. *Borassus Flabellifer* Linn.).

BAWA KARTAR SINGH, Allahabad, *and* ABDUL MAJEED, Patna.

The work was undertaken with the object of finding out whether the palm fruits of the palmyra palm (Lat. *Borassus Flabellifer* Linn.) which grows abundantly in Bihar and United Provinces could be utilized as a source of palm oil and palm kernel oil. The suggestion was made by a soap expert that this palm, like the African oil palm (*Elacis Guineensis*), may contain oil. The conclusions derived from the chemical examination of the pulp and the kernel of the fruits of palmyra palm are given below:—

1. The oil-content of the dry pulp of the different forms of the fruit of palmyra palm (*Borassus Flabellifer*) varies 0·6 per cent to 0·9 per cent and that of the kernel from 0·4 per cent to 0·5 per cent. It is thus clear that unlike the African oil palm (*Elacis Guineensis*), the palmyra palm is devoid of oil.

2. The sugar-content of the *Harna* form is about 48 per cent that of *Jogia* about 50 per cent and that of *Doma* about 56 per cent. It agrees with the observations that *Harna* is the least sweet and *Doma* the most sweet of the three locally known forms of the fruits of the palmyra palm.

3. The dextrin-content of the pulp of *Harna* and *Jogia* forms varies from 15 to 16 per cent, whereas it is as low as 9 per cent for the *Doma* form. This indicates that the lower dextrin-content of the pulp of the *Doma* form is due to some of this substance having been converted into sugar.

4. The total weight of the constituents of the kernels of the different forms of fruits of palmyra palm varies from 24 to 28 per cent. It may, therefore, be inferred that the kernel contains a high percentage of a substance or substances which are easily hydrolyzed when treated alternately with 1·25 per cent sulphuric acid and 1·25 per cent sodium hydroxide.

158. Examination of *eucalyptus* oil.

P. C. GUHA, Bangalore.

3 cwts. of eucalyptus leaves procured from the Nilgiris were distilled with steam to yield about 6 lbs. of the oil. By a series of systematic fractionations, the cineol and pinene present in the oil were separated in a pure state. The purity of the cineol thus prepared was established by oxidizing a portion of it to cineolic acid.

After separating the cineol and the pinene, the sesquiterpene fraction of the oil was isolated. The chemical nature and the physical properties of the sesquiterpene fraction are under investigation.

The industrial possibility of preparing cineol by the method outlined above is being explored.

159. Utilization of Indian turpentine oil. Part I. On synthetic camphor.

P. C. GUHA *and* A. N. ROY, Bangalore.

Turpentine oils from the resins of *Pinus longifolia*, *Pinus excelsa*, *Pinus khasia* and *Pinus merkusii* have been examined. Oil from *Pinus longifolia* (obtained from Jallo) has been found to contain about 40% of a mixture of α- and β-pinenes and about 50% of Δ^3, Δ^4-carenes. Very high yield of pure α-pinene (96%) was obtained from the oil of *Pinus merkusii*.

Direct conversion of α-pinene and a mixture of α- and β-pinenes to borneol esters with acetic acid, acetic anhydride in the presence of catalysts like boric acid-anhydride, phosphorus pentoxide, etc., have been tried and the yield of bornyl acetate studied.

Isomeric transformation of α-pinene and β-pinene to camphene in the presence of organic, inorganic and complex acid catalysts have been studied with encouraging results in some cases.

The method of direct conversion of pinenes to borneol esters have been extended to a mixture of pinene and camphene and a yield of 60% borneols obtained. The yield was much lower in the case of the pinene-camphene mixture containing small amounts of carenes.

Borneol and isoborneol mixture has been successfully oxidized by nitric acid to camphor.

160. Utilization of Indian turpentine oil. Part II. On the possibility of conversion of Δ^3-, Δ^4-carenes into thymol, menthol and other synthetic aromatics.

P. C. GUHA *and* A. N. ROY, Bangalore.

Thymol and menthol can be manufactured from *p*-cymene provided the cost of *p*-cymene is low. Carene has been dehydrogenated with sulphur and an yield of 40 per cent of *p*-cymene has been obtained.

Further work is in progress to improve the yield of *p*-cymene by using catalysts along with sulphur.

Action of various organic and mineral acids on carene have been studied. Organic acids and dilute mineral acids have almost no action on carenes. Carenes polymerize in the presence of a mixture of strong sulphuric and acetic acids. Gaseous hydrochloric acid and hydrobromic acids react with carene to form dihalogen compounds of dipentene and sylvestrene which on treatment with zinc and subsequent hydrolysis yields a complex mixture of terpenes possessing nice aromatic odour.

161. Utilization of Indian turpentine oil from *Pinus longifolia.*

P C. GUHA *and* M. S. MUTHANNA, Bangalore.

Polymerization products obtained from turpentine oil are reported to be used as plasticizers (Tischtchenko and Rudakov, *Prom. Org. Chim.*, 1937, **4**, 555). Bakelite or galalith type of plastics are not affected by the addition of 10 per cent of the polymerides. But the incorporation of the dimeride with urea-formaldehyde resins are reported to have definite advantages (Rutovski, Andrianov and Lebedev, *Prom. Org. Chim.*, 1937, **4**, 104). The elasticity of the resin and its resistance to water and ammonia are increased, whilst its hygroscopicity is reduced. The common variety of Indian turpentine oil (from chir pine) with its low contents of pinene and high content of Δ^3-carene (about 50%) does not appear to be very suitable for the preparation of synthetic camphor and renders its use relatively more limited than other turpentine oils (e.g. from *Pinus excelsa*, etc.) with higher percentage of pinene, and has now been found to offer itself as a convenient material for the preparation of the dimeride.

After a number of experiments with different strengths of sulphuric acid under varying conditions of experiment, it has been found that reaction of conc. sulphuric acid with Indian turpentine oil gives from 65 to 70% of the dimeride ($C_{20}H_{32}$, b.p. 195–198°/25 mm.; n_D^{25} 1·518; d_4^{20} 0·9256), together with 20 to 25% of a mixture of terpenes.

162. Modification of shellac with organic dibasic acids.

H. K. SEN, Ranchi.

Shellac has been treated with different organic dibasic acids like oxalic, malonic, succinic, subaric, sebacic in dioxane solution in presence of *p*-toluene sulphonic acid as catalyst.

The product with anhydrous oxalic acid gives a transparent pliable thin sheet on evaporation of the solvent and that with sebacic acid gives a resin which can be drawn into fine pliable silky thread having considerable strength.

163. Influence of specific chemical groups on the solubility of resins.

H. K. SEN, Ranchi.

Studies have been made on the influence of different chemical groups on the solubility of shellac (pure resin) in acetone, gum dammar in ether and kauri gum in ethyl acetate. All the above resins have a component which properly purified and dried is insoluble in the above solvents respectively. But the addition of a small quantity of other substances to these confer to them solvent power for these resins. It has been observed that though polarity of the added substance is an important factor, nevertheless, the specific chemical groups contained in the added

substance have more powerful and immediate effect. For example, any compound containing hydroxyl or carboxyl groups can effect solubility of shellac or kauri in the above solvents and this solubilizing power is not parallel with the dipole moments of the compounds. Any hydrocarbon type compound also does the same for dammar in ether, benzene and its homologues being very powerful in this respect.

The influence of the added substances has been measured either by directly determining the smallest quantity of them necessary to dissolve a given quantity of the resin in a fixed quantity of the above non-solvents or by measuring the viscosity of the resulting solutions containing equimolecular quantities of the added substance. The two methods give almost the same order for solubilizing power of the substances so far studied.

164. Shellac-protein moulding compositions.

H. K. SEN, Ranchi.

The use of casein in preparing shellac moulding compositions have been described in an earlier publication. (*Ind. Lac. Res. Inst.*, Research, Note No. 21, 1940). The work has been extended to the use of other vegetable proteins chiefly from karanja cake (*Pongamia glabra*) and soyabean (*Glycina hispida*) with a view to obtain cheap shellac moulding compositions of high heat resistance. The proteins are prepared by sodium chloride extraction and dilution. The proportions used for the compositions are:—

Shellac ..	.. 30 parts in ammonium hydroxide.
Soya bean protein or Karanj cake ..	.. 4·5 parts ,, ,,
Phenol ..	.. 1·2 parts.
Pigment ..	.. 2·5 parts.
Calcium stearate ..	.. 1·25 parts.
Lime ..	.. 0·60 parts.
Wood-flour 80–100 mesh	.. 30·00 parts.

The above compositions after sufficient mixing, kneading and drying can be worked on the bakelite technique by pressing at 145°C. and removing at the same temperature after 2-3 minutes' curing. Some of the chief physical properties of the test compositions are given below:—

(1) Impact strength ..	.. 4 cm. kg. per sq. cm.
(2) Water absorption (24 hours)	.. 10–12%.
(3) Heat resistance ..	.. 94-95°C.

The resin solution without filler can be utilized for leather finishings and preparation of laminated sheets. Attempts are in progress for improving the water resistance and also for preparing transparent and flexible resin films.

165. Further researches on 'oil plastic'.

M. GOSWAMI *and* A. CHOUDHURI, Calcutta.

In continuation with our work on the oil plastic discovered by one of us we have been successful in making it thermohardening. It has been found that the resins derived from oils and fats generally soften between 120–130° and the thermohardening resin can be moulded at 200°C. Improvements have been made to avoid gas-formation at this high temperature.

166. Shellac moulding powders.

H. K. SEN, Ranchi.

The use of shellac in plastic moulding for the production of electrical and other useful articles is restricted due to its comparatively high brittleness and low softening temperature. The former is readily eliminated by using fibrous fillers while the latter is overcome by suitable modification with formaldehyde in the presence of materials like urea, melamine, and guanidin carbonate. These can be readily manufactured from technical calcium cyanamide and processes for the production of these on a commercial scale have been worked out in these laboratories.

Shellac-formaldehyde-melamin moulding powder for compression moulding.

Shellac (100 lbs.) is dissolved in boiling rectified spirits (25 gallons) and then treated with formalin (20 lbs.) for 1 hour. Melamin (5 lbs.) is now added and the boiling continued for another hour after which the hot solution thus obtained is well kneaded with wood flour (100 lbs.), pigment (2·5 lbs.) and calcium stearate (2·5 lb.). The powder is then dried, ground to 60 mesh in a Christy and Norris disintegrator and finally dried in vacuum at 70-75°C. for 2 hours. The powder may be moulded at 140–145°C. and ejected from the moulds at the same temperature. Switches, ceiling-roses and other articles have been made on the commercial scale with success.

Shellac-formalin-guanidin carbonate moulding powder for injection moulding.

This powder is also made in exactly the same way as above except that guanidin carbonate and jute are used in place of melamine and wood flour respectively. The following composition has been found to yield the best results:—

Shellac	100 lbs.
Rectified spirit	8 gallons.
Formalin	33 lbs.
Guanidin carbonate	5 lbs.
Jute	66·6 lbs.
Pigment	33·3 lbs.
Calcium stearate	2·5 lbs.

The powder has been found to flow freely at 125–130°C. in the injection moulding press at 25–30 atmospheres pressure. Articles such as bottle caps and electric switches have been made on a large scale. These are sufficiently heat and water resistant. Its use for such and other similar electro-technical goods are to be recommended.

167. Dielectric strength of films of Uro-lacs.

P. S. SARMA, V. RAMA RAO, *and* M. SREENIVASAYA, Bangalore.

In a previous communication (*Current Science*, 1938, 7, 49) we have reported upon the dielectric strength of lacs of known origin. The effect of the addition of urea on the dielectric strength of films have been investigated employing the technique similar to that described in Appendix I of B.S. Specification No. 119 of 1930. The brass test electrodes were each $1\frac{1}{2}''$ in diameter with rounded edges. The weight of the top electrode was approximately 1 lb. and the bottom electrode was maintained at earth potential. The voltage between them was increased at a uniform rate until the film punctured. The maximum reading of the voltmeter connected to the tertiary winding of the transformer, was noted at each breakdown. The results reveal a fifty to hundred per cent increase in the dielectric strength of lacs treated with urea under different conditions.

168. Anticorrosive varnishes.

G. M. AJMANI *and* S. K. K. JATKAR, Bangalore.

Rosin modified cresylic acid resins suitable for making anticorrosive varnishes, from the cresols, supplied by Bararee Coke Company through the Industrial Research Bureau, have been prepared. The physical properties of oil varnishes made from the above resin and cashew shell oil resins, have been measured. The films are found to be remarkably hard, elastic and resistant to the action of petrol, lubricating oil, strong acids and prolonged heating at 130°. The films show dielectric strength of more than 1,000 volts per mil. It has been found that the above resins can replace Chinese wood oil in the preparation of baking varnishes.

169. Shellac-protein plastic.

J. L. SARIN *and* M. Y. UPPAL, Lahore.

A new plastic has been prepared from shellac and gram flour. Shellac (50 per cent) and specially prepared gram flour (50 per cent) are mixed and pressed in a hydraulic press under a pressure of 5,000 lbs. per sq. inch at 180 to 190°C. The new plastic has the following properties:—

Sp. Gr.	1·32
Sp. Vol.	21·0 in.^{3} per lb.
Bulk Factor	3·2
Tensile Strength	700 to 1,800 lbs. per sq. in.
Dielectric Constant	8·0
Thermal Conductivity	$3{\cdot}3 \times 10^{-4}$
Sp. Heat	0·51
Sp. Resistance	$0{\cdot}55 \times 10^{15}$

Further work in improving the tensile strength of the plastic is in progress.

170. Preparation of edible sugar syrups from cane molasses.

K. ASWATH NARAIN RAO, Cawnpore.

While the consumption of table syrups is very large in other countries, especially in the U.S.A., the market is limited in India at present, the chief reason being perhaps its high cost. A method has been developed whereby it is possible to manufacture profitably a satisfactory table syrup from cane molasses. Quicklime precipitates under special conditions about 80–85% of the sugars in molasses. The lime-sugar compounds are decomposed by carbon dioxide, the resulting sugar solution being suitably treated and concentrated to a syrup of 75–80° brix. This syrup keeps well and compares favourably both as regards taste and colour with similar products in the market, which, it may be mentioned, are prepared from refined sugar. The syrup can be used as a cheap and valuable article of diet for the troops.

171. Utilization of locally available fruits. 1. Preservation of citrus juices.

C. J. DASA RAO, Waltair.

The locally available citrus fruits have been classified into three groups, *Citrus aurantium, Citrus medica* and *Citrus decumana*. The juices of these fruits are sweet, sour and bitter in taste, respectively. A detailed analysis of the juices has been carried out with regard to their

sugar, acidity, ash and vitamin content. Taking this analytical data into consideration, experiments were conducted to find out the best conditions for their preservation. The costs of production of these juices at Waltair on a semi-commercial scale have been worked out.

172. A study of the chemical properties of pit-tanned buffalo sole leather and a tentative chemical specification for it.

B. M. DAS, B. B. DHAVALE, *and* B. N. PAL, Calcutta.

The chemical properties of pit-tanned buffalo sole leather have been studied and a tentative specification, based on the study has been out, which is thus:—

1.	Degree of Tannage	55–80
2.	Hide substance	42–53%
3.	Combined Tannin	25–36%
4.	Insoluble ash should not be more than ..	0·5%
5.	Water-soluble matter should not be more than	12·5%
6.	Water-soluble matter per unit of hide substance should not be more than ..	0·3
7.	Fat should not be more than.. ..	3·4%

173. Economic utilization of Punjab reeds.

J. L. SARIN, Lahore.

A collection of reeds growing wildly have been collected from all over the Punjab specially from marshy places and sandy river banks. They were examined with a view to utilize them in the preparation of some articles of commercial value. Besides reeds, long fibre leaf, etc., have been examined and it has been found that date palm leaf after bleaching and dyeing can be made to give some products of economic utility. The leaves were bleached with bleaching powder and chlorine and dyed with direct synthetic dyes. So far sola hat lining has been successfully prepared and sample sent to the market have been well reported upon.

174. Cellulose content of some South Indian fibres.

K. RAMAMURTI, Madras.

The possibility of obtaining high grade cellulose from agricultural wastes and other fibrous materials has been examined. The α-cellulose, Cross and Bevan cellulose and lignin content of a number of materials have been studied and the copper number of the celluloses prepared from them determined. The α-cellulose content of the most promising materials were:—

Banana tree—petiole and mid-rib	60·3%
Hibiscus sabdariffa	82·8%
Cholam	60·9%

The copper number of the cellulose prepared from these sources were 1·78, 0·75 and 1·37 respectively.

175. Estimation of α-cellulose in Mandya Begasse.

P. C. GUHA *and* A. KUPPUSWAMI, Bangalore.

With a view to find out their applicability in the manufacture of artificial silk, the α-cellulose contents of various indigenous soft woods have been determined by the chlorine gas method of Schorger (*Chemistry*

of Cellulose and Wood, 1926, 512). The following are the results for the Begasse from the Sugar Factory at Mandya :—

Samples.	Percentage of cellulose.	Percentage of α-cellulose.
1	51·03	48·26
2	52·21	49·12
3	51·73	47·47
4	53·11	48·75

176. Oxycellulose and hydrocellulose. The properties of different types of oxycellulose.

S. M. KAJI *and* K. VENKATARAMAN, Bombay.

It was shown by Clibbens and Ridge that two extreme types of oxycellulose could be formed by the action of oxidizing agents on cellulose. The main difference exhibited by the two types was as regards reducing power and methylene blue absorption. Basing our experiments on the Haworth formula for cellulose, it has been possible to establish the identity of at least 4 types of oxycellulose. For this purpose, it was necessary to determine the reducing power, viscosity, carboxyl content, metal affinity and ability to couple with diazo salts. Samples of oxycellulose conforming to the four types were prepared by the action of oxidizing agents such as acidic and alkaline hypochlorite, sodium hypobromite acidic and alkaline permanganate, caustic soda, mildew, heat, singeing, ultra-violet light, etc. Reducing power was determined by Heyes' micro copper number method, viscosity in cuprammonium solution by the Shirley Institute procedure, and carboxyl content by Neale's method as modified by Scholefield, Nabar and Turner (*J. Soc. Dyers Col.*, 1937, **53**, 5). For determination of metal affinity, it was found that the Thomas tests (*J. Soc. Chem. Ind.*, 1933, **52**, 79J) depending on the production of Turnbull's blue and Prussian blue were not satisfactory for some of the samples, and the copper-rubeanic acid method previously standardized by the authors was applied. Of the numerous diazo salts examined, Trivasol Red B was found to be the best as regards its coupling power, and the distinction between oxycellulose and hydrocellulose was sharper than in the case of other salts. The slight staining of the samples which occurred in these cases in which there was no coupling power was removed by vigorous soaping. It was found that samples prepared by alkaline oxidation had high carboxyl content, low reducing power, great metal affinity and coupling power, while those prepared by acidic oxidation exhibited low carboxyl content, great reducing power, and no metal affinity, but were capable of coupling with diazo salts. Certain oxycelluloses, such as those produced by heat, had very low reducing power, an insignificant percentage of carboxyl, slight metal affinity and no coupling power. The products of mildew action, where the degradation was not drastic, showed only reducing power in the absence of other characteristics. In the case of hydrocelluloses prepared under widely different conditions, no qualitative distinction in properties was noticed. The degradation of cellulose to hydrocellulose is, therefore, linear and regular, representing a single type of reaction, while a series of reactions may go on either individually or simultaneously in the formation of oxycellulose. Thus one end of a terminal glucopyranose unit of a hydrocellulose may be oxidized to a di-aldehyde, or to a mono-carboxylic acid or to an aldehydo-carboxylic acid and ultimately to a di-carboxylic acid. Oxidation of the primary alcoholic group may be accompanied, preceded or followed by the oxidation of the 4-CHOH group to carbonyl, leading to a β-ketonic aldehyde or acid, such a product being capable of coupling with diazo salts.

177. A new method for determining the efficiency of wetting agents.

S. V. VENKATACHALA, K. S. GURURAJA DOSS, *and* B. SANJIVA RAO, Bangalore.

A method has been worked out for determining the efficiency of wetting agents. A weighed skein of grey yarn is shaken with the solution of the wetting agent on a shaking machine for half a minute. It is then taken out and rolled fifteen times under water with a half-pound roller to remove the entrapped air. The yarn is then weighed under water. To enable quick weighing a sensitive torsion balance has been improvized from a Du Nouy tensiometer. The apparent density of the grey yarn is calculated therefrom. The apparent density multiplied by 100 is designated the Apparent Density number (or A.D. number). The A.D. number is a measure of the degree of wetting. The A.D. number for distilled water is about 49 The maximum value for the A.D. number is of the order of 155. The efficiencies of some commercial wetting agents have been determined by this method. Effect of addition of capryl and amyl alcohols on the efficiency has been studied. The results indicate the formation of complexes between the molecules of the wetting agent and capryl alcohol molecules.

178. Some aspects of the constitution of wetting agents and detergents.

S. I. TARAPOREWALA, *and* K. VENKATARAMAN, Bombay.

In a previous communication mention was made of the marked wetting power exhibited by the sodium salts of half esters of a number of dicarboxylic acids. The behaviour in textile processing of a series of compounds of this type has now been quantitatively studied. Sulphonation and sulphation being usually a necessary stage in the preparation of wetting agents, various conditions under which compounds such as aromatic dicarboxylic esters, fatty alcohols, alkyl ethanolamides and alkyl naphthalenes could be sulphonated or sulphated have been examined. The alkyl ethanolamides of caprylic, capric, lauric, myristic, palmitic and stearic acids were first prepared by the condensation of the corresponding acid with monoethanolamine, and these amides were then sulphonated with fuming sulphuric acid. A compound allied to the commercial wetting agent Nekal BX has been prepared by the sulphonation of diamyl naphthalene.

The preparation of new wetting agents by the condensation of a carboxylic acid with an aminocarboxylic acid has been attempted. Compounds of this type are the sodium salts of lauryl and oleyl anthranilic acids. The sodium salt of sulphonated butyl *n*-oleylanthranilate has also been prepared for comparison with the above and with oleylanilide-*p*-sodium sulphonate.

While the outstanding properties of a commercial textile auxiliary agent, a taurine derivative, are recognized in Indian mill practice, its precise constitution is somewhat uncertain in regard to the presence or absence of an *n*-methyl group. From this point of view and that of the general objectives of this work, a series of long chain fatty acyl derivatives of taurine have been synthesized and their properties (wetting power, resistance to hard water, detergent action, etc.) determined.

In order to examine the relation between the physico-chemical properties of a wetting agent, specially protective colloidal action, and detergency, detergency trials on standard soiled cloth have been made with a series of sodium and triethanolamine soaps, sulphonated oils and commercial wetting agents. Starches, such as maize and wheat, a colloidal clay (Wilkinite), and gelatine, were also included, as they were

considered of particular interest from the point of view of the significance of protective colloidal properties in a detergent. The scouring was done under standard conditions, and after the scouring, part of the cloth was submitted to a standard bleaching process. The whiteness, wettability and wax content of the scoured and bleached samples were then determined. The protective colloidal action of these textile auxiliaries was determined in terms of the Congo Rubine number.

In the course of a study of the Congo Rubine technique the relation between temperature and Congo Rubine number for a number of soaps has been determined, since the temperature of scouring is a vital factor in detergent operations.

179. Wetting agents: Derivatives of C-alkyl and alkoxy-anilines.

B. D. Tilak *and* K. Venkataraman, Bombay.

Since lauryl-*p*-toluidine-2-sodium sulphonate was found to be an excellent wetting agent, a series of wetting agents were prepared by condensing *p*-toluidine-2-sulphonic acid with palmityl and stearyl chlorides and the chlorides of fatty acids from coconut, groundnut, cotton seed and mowhra oils. In addition to the standard procedure for the reaction described in previous communications, it has been found feasible to effect the condensation in acetone and in water in presence of alkali. To observe the influence of the position of the C-alkyl group with respect to the amino group on wetting power, condensates of lauryl and oleyl chlorides with *o*-toluidine-4-sulphonic acid were prepared. *p*-Anisidine was sulphonated with 20% fuming sulphuric acid and the *p*-anisidine-2-sulphonic acid was condensed with lauryl and oleyl chlorides to give the corresponding lauryl and oleyl derivatives. *p*-Phenetidine-2-sulphonic acid was similarly prepared and condensed with lauryl and oleyl chlorides to give the corresponding *n*-acyl derivatives. Sulphonating *p*-anisidine with sulphamic acid, by analogy with the sulphonation of *p*-toluidine with sulphamic acid which yields *p*-toluidine-3-sulphonic acid, the 4-aminoanisole-3-sulphonic acid thus obtained was converted into lauryl- and oleylanisidine-sulphonic acids. The ethoxy analogues derived from *p*-phenetidine were also prepared. Employing the methods described in previous communications (*J. Soc. Dyers Col.*, 1937, **53**, 91, *et sequa*), the properties of the new wetting agents derived from C-alkyl and alkoxy anilines, have been determined.

180. Textile auxiliary agents from cashew nut-shell oil.

R. C. Gandhi *and* K. Venkataraman, Bombay.

On account of its powerful antiseptic properties and its constitution as a C-pentadecadienylsalicylic acid, leading to marked wetting power, anacardic acid, the essential constituent of cashew nut-shell oil, is a useful raw material for the preparation of wetting agents for textile processing and of textile antiseptics (Gandhi and Venkataraman, *Current Science*, 1939, **8**, 367). Keeping these two specific requirements in view, numerous synthetic schemes on anacardol, anacardic acid, tetrahydroanacardol and tetrahydroanacardic acid have been instituted, some of which were described in a previous communication (*Proc. Ind. Sci. Cong.*, 1940, Part III, p. 96). As indicated by the difficulty in esterification and in conversion to the acid chloride under normal conditions, the carboxyl group in anacardic acid is probably in the *o*- position both to the hydroxyl and the alkyl groups, which have been shown by Shah and his collaborators (*Current Science*, 1940, **9**, 357) to be *m*- to each other. The preparation of the arylamides of anacardic and tetrahydroanacardic acids could, however, be effected by treatment of a pyridine solution of the acid and

the amine with phosphorus trichloride. Besides the substituted anilines and the naphthylamines, the amines employed in the preparation of these antiseptics were benzidine, dehydrothiotoluidine, sulphanilamide and *p*-amino-*p*-toluenesulphonanilide. For purposes of comparison the salicylic acid analogues were also prepared. In order to impart surface activity to salicylanilide, which is in use as a textile antiseptic, and to provide synthetic analogues of the type described above and derived from anacardic acid, two methods were employed. Salicylic acid was condensed with phenylene diamines mono-acylated with lauric, palmitic and stearic acids; secondly, 5-aminosalicyclic acid was N-acylated with a series of fatty acids by treatment with the acid chlorides in dioxane solution, the 5-acylamidosalicylic acids being then converted into the corresponding anilides.

181. Separation and purification of the ingredients of light and middle oil from coal tar.

P. C. GUHA *and* AJOY GUPTA, Bangalore.

Benzene, toluene, xylene, naphthalene, pyridine, pyridine bases, phenol and phenolic bodies have been isolated from light and middle oil procured from Bengal Chemical and Pharmaceutical Works and also from tar oils of Bombay Gas Company and Shalimar Works, first on a laboratory scale followed by semi-commerical operations. Preparations of α- and β-naphthalene sulphonic acids, β-naphthol and phthalic anhydride have also been successfully undertaken.

182. Preparation of some important benzene derivatives on a semi-commercial scale.

P. C. GUHA *and* N. C. JAIN, Bangalore.

Crude benzol (20 gallons) obtained from light oil fraction of the tar oil has yielded 1- gallons of pure benzol, b.p. 78–80° in one operation. By the action of chlorine 24 lbs. of benzene in one operation has yielded 20 lbs. of chlorbenzene, b.p. 130–32°.

From chlorbenzene, *o*-nitrochlorbenzene, *p*-nitrochlorbenzene, and 2 : 4-dinitrochlorbenzene have been successfully prepared. The preparation of other commercially important derivatives from the above three substances, as also the preparations of *p*-dichlorbenzene, benzene sulphonic acid, benzene *m*-disulphonic acid are in progress.

183. Catalytic thionation. Part I. The preparation of primuline base and dehydrothiotoluidine.

R. D. DESAI *and* P. N. JOSHI, Bombay.

Sulphuration of organic compounds is one of the important reactions in the manufacture of dyestuffs either for the preparation of the intermediate or the finished products. We have observed that the yield of the primuline base in the reaction between toluidine and sulphur is greatly improved by using iodine as a catalyst. We are studying this reaction with the intention of discovering the best conditions of time and temperature for the preparation of primuline in maximum proportion, in presence of various catalysts and specially iodine, $AlCl_3$, $FeCl_3$, and cuprous salts. We are also extending this reaction to a mixture where α- and β-naphthylamines, have partly replaced a molecule of toluidine so as to obtain naphthathiazole derivatives analogous to dehydrothiotoluidine.

184. Vegetable dyes. Part I. Dyeing with *Butea frondosa* (Palas) flowers.

P. N. JOSHI *and* R. D. DESAI, Bombay.

The specimen of flowers of *Butea frondosa* were submitted by the Director of Industries, Bombay Province, for the investigation of dyeing trials, so as to find some remunerative use for them for the dyeing purposes. We have investigated the methods of extraction either with water or without water containing HCl. Dyeing of wool has been attempted on chromium, tin, aluminium and iron mordants, and some shades obtained by us are really interesting and they have good general fastness properties. However, our shades with different mordants differ from those described by Perkin and Everest (Natural Organic Colouring Matters, pp. 166–171). Therefore, it is supposed that the variety of *Butea frondosa* examined by Perkin and Everest may have been different from the one we have investigated.

185. Studies in the naphtol AS series. Dyes derived from cashew nut-shell oil.

R. V. BHAT, S. R. RAMCHANDRAN *and* K. VENKATARAMAN, Bombay.

The factors concerned in the fastness to rubbing of azoic dyeings have been discussed elsewhere (*J. Soc. Dyers Co.*, 1938, **54**, 216, *et sequa*; *Current Science*, 1939, 8, 286). In the light of Hartley's theory regarding the solvent action of soaps and synthetic detergents on organic compounds insoluble in water, the after-treatment of azoic dyeings by a series of detergents of known chemical constitution has been studied. A new approach to the problem would seem to be to take advantage of the tendency of organic compounds to dissolve in solvents to which they are closely related in structure, and to synthesize naphthols of soapy character in order to increase the solubilizing and emulsifying action of soap solution on the resultant azoic dyes, precipitated on the fibre. Anacardic acid, being a salicylic acid carrying a long paraffin chain attached to the nucleus, appeared to be a cheap and readily available raw material for the synthesis of arylamides capable of application to cotton as a Naphtol. The aliphatic chain being doubly unsaturated, a certain amount of substantivity may be anticipated (*cf.*, Bhat, Forster, and Venkataraman, *J. Soc. Dyers Col.*, 1940, **56**, 166). Arylides of anacardic acid might also prove of interest in producing anticrease effects on the azoic dyed materials. Textiles dyed with arylides of anacardic acid and diazo salts would be less liable to mildew attack (*cf.*, Gandhi and Venkataraman, *Current Science*, 1939, **8**, 367). In view of these considerations, anacardic acid and tetrahydroanacardic acid have been condensed with various bases such as aniline, α- and β-naphthylamine, benzidine and *o*-dichlorobenzidine and properties of the ice colours derived from the arylides examined.

By the interaction of the reduction product of Naphtol AS-BS (the *m*-nitroanilide of β-hydroxynaphthoic acid) with anacardic acid and tetrahydroxyanacardic acid chlorides, two other naphthols of the general type mentioned above were obtained, but these possess the additional interest that they are capable of coupling in two positions, in the naphthol half and the salicylic acid half of the molecule respectively.

186. Studies in the naphtol AS series: Naphthols of high substantivity.

R. V. BHAT *and* K. VENKATARAMAN, Bombay.

New naphthols have been prepared with the object of studying the influence of chemical constitution on substantivity towards cotton

and on the fastness of the dyeings. In comparison with β-naphthol, the acylamido-group (CO-NH) in Naphtol AS and its analogues may be regarded as being responsible for the increase in substantivity of the Naphtols and the improvement in the fastness properties of the developed dyes on the fibre. This has been confirmed by the synthesis of new naphthols containing a second carboxylamide group, obtained from the condensation of β-hydroxynaphthoyl chloride with bases such as N-benzoyl-*m*-phenylenediamine, *p*-aminobenzanilide and *m*-aminobenzanilide.

The low substantivity of *m*-(2′-hydroxy-3′-) naphthoylamido-*p*-toluenesulphonanilide (Bhat, Forster, and Venkataraman, *J. Soc. Dyers Col.*, 1940, **56**, 177) was ascribed to the sulphonamide group responsible for its ready solubility and its non-colloidal character. The hydrogen of the sulphonamide group was, therefore, replaced by a methyl, hydroxynaphthoyl derivatives of N-methyl-N-*p*-toluenesulphonyl-*m*-phenylenediamine and N-methyl-N-*p*-toluenesulphonyl-*p*-phenylenediamine being prepared. Other examples of sulphur containing naphthols are the hydroxynaphthoyl derivatives of *p*-toluenesulphonyl-*p*-phenylenediamine and 2-aminothiazole.

By the interaction of 2-hydroxy-3-naphthoyl chloride with *p*-aminobenzoyl-α-aminoanthraquinone, a vat colour similar to Indanthrene Yellow GK and Indanthrene Brilliant Violet RK has been obtained; it also represents a new naphthol type capable of coupling in the normal way with diazo-salts. The substance may thus be applied to cotton as a vat colour and after-treated with diazo-salts. The constitution of hydroxynaphthoyl derivatives of α-aminoanthraquinone, 1 : 4-, 1 : 5- and 2 : 6-diaminoanthraquinones, described earlier, has been elucidated.

The influence of ketonic groups on substantivity and fastness properties is shown by the hydroxynaphthoyl derivatives of *p*-aminoacetophenone and *p*-aminobenzophenone.

2-Hydroxy-3-naphthoyl chloride has been condensed with 1 : 2- and 1 : 8-diaminonaphthalenes. While the reaction proceeded normally in the case of 1 : 2-diaminonaphthalene, only one amino group of the 1 : 8-isomer proved to be reactive.

In order to synthesize 3-benzylideneaceto-2-naphthol, a new type of 'naphthol' containing no nitrogen in the molecule, attempts have been made to prepare 3-acetyl-2-naphthol in quantity. Following the method of Shah, the methyl ether of Naphtol AS was condensed with aniline. The urethane derivative of the amidine was reduced to 2-methoxy-3-naphthaldehyde, which gave a characteristic 2 : 4-dinitrophenylhydrazone. The aldehyde was then converted into the ketone by means of diazomethane, but the ultimate yield of the required ketone was poor and alternative methods of preparation are being examined.

187. Further synthetical experiments in the naphtol AS series.

D. M. Patel *and* K. Venkataraman, Bombay.

The essential correctness of our premises regarding the relation between chemical constitution and substantivity to cotton in the Naphtol AS series has been shown by the superior substantivity of the newly synthesized naphthols in comparison with Naphtol AS (*cf.*, Bhat, Forster, and Venkataraman, *J. Soc. Dyers Col.*, 1940, **56**, 160; and preceding abstract). While this has therefore become a factor capable of control, attention is now being directed to a study of the influence of specific groups and orientations on other properties, such as colour, tinctorial power and fastness, in addition to substantivity. Among the direct dyes derived from symmetrically constituted diamines, such as benzidine, derivatives of *m*-substituted benzidines and of *p*-diaminodiphenylmethane and *p*-diaminodibenzyl are non-substantive, the significant feature for

the production of substantivity being apparently a rigid and linear alignment of the rings carrying the two amino groups. While benzidine-*m*-disulphonic acid and *m*-tolidine do not yield direct dyes, substantivity is restored when these are replaced by benzidine-sulphone and diaminofluorene. Parallel effects in the Naphtol AS series have been investigated by the condensation of hydroxynaphthoic acid with *p*-aminoazobenzene, *p* : *p*-diaminoazobenzene, *o*- and *p*-aminodiphenyl, *m*-tolidine, *p* : *p'*-diaminodiphenylurea, and benzidine-sulphone. In the last case, for instance, a naphthol of high substantivity was obtained. The effect of unsaturation on substantivity was indicated by the greater substantivity of the naphthols derived from monocinnamoyl- and mono-*p*-methoxycinnamoyl-*p*-phenylene diamine in comparison with the *p*-benzamidoanilide of hydroxynaphthoic acid. Extending the syntheses of naphthols derived from the amino-anthraquinones, which therefore possess vat dyeing properties simultaneously, compounds which have the advantage of readier solubility in caustic soda, essential for application as Naphtols, have been prepared by introducing a *p*-toluenesulphonamido group in hydroxynaphthoylamidoanthraquinones. 4-Aroyl-1-naphthols, coupling in the 2-position and leading to alkali-insoluble azoic dyes, are known to be of some practical use; 2-acyl-1-naphthols and diketones, such as 2-benzoylaceto-1-naphthol prepared by the action of sodamide on 2-acetyl-1-naphthyl benzoate (Mahal and Venkataraman, *J. Chem. Soc.*, 1934, 1767), are being explored in regard to their utility as Naphtols. The diketone referred to is capable of coupling in two positions, one of them being the reactive methylene group; the possibility of cyclization to naphthaflavones opens up a new method of after-treatment for improvement in fastness properties.

188. Manufacture of acetic acid and other products.

P. C. GUHA *and* N. PITCHANDI, Bangalore.

Acetic acid has a wide use in chemical industry in the preparation of various acetates, chemicals, etc., and for the coagulation of latex in rubber plantations. Since the outbreak of war supplies of this product in our country has suffered very much. Manufacture of acetic acid by the decomposition of lime acetate (57 lbs.) produced at Bhadravati by sulphuric acid was studied and 80% crude acetic acid (about 40 lbs. per day) was obtained in a copper plant made here. The concentration of the 80% acid to glacial acetic acid by azeotropic distillation using various entrainers has been effected. (i) The extraction of acetic acid direct from pyroligneous acid, (ii) the manufacture of ethyl acetate using lime acetate, alcohol and hydrochloric acid, (iii) sodium acetate from weak acetic acid fractions, and (iv) acetic anhydride from sodium acetate have also been studied.

189. A comparative study of some of the methods commonly employed for preparing absolute alcohol.

N. VENKATANARASIMHACHAR, Bangalore.

The new method for determining the percentage of water in absolute alcohol (based on measurements of electrical conductivity of alcohol saturated with sodium chloride) worked out in this laboratory has now been employed to investigate the efficiency of the different methods for the preparation of absolute alcohol. It has been shown that a single distillation of about 95% alcohol (from the Mysore Sugar Co., Mandya) with excess of good quality quick-lime can easily give an alcohol con-

taining less than 0·05% of water. Calcium and sodium are found to be equally efficient in removing the last traces of water.

190. Catalytic manufacture of ethyl acetate from alcohol.

R. V. JOGLEKAR *and* S. K. K. JATKAR, Bangalore.

Decomposition of alcohol is effected by conducting vapours of alcohol at atmospheric pressure over a catalyst containing copper, aluminium and chromium oxides at 275°C. About 20% of the alcohol passed at the 100 c.c. per hour is converted into ethyl acetate and 60% into acetaldehyde.

191. Manufacture of mannose.

E. K. NARAYANAN, Calcutta.

As large quantities of mannose are being used in bacteriological work, especially connected with cholera, and as the sugar is somewhat prohibitive in cost, its preparation on a large scale, from the endosperm of the vegetable-ivory-nut *Phytelepas macrocarpa*, is being undertaken. The raw material for this preparation is imported from America as a meal which is the by-product of button manufacture. The method of preparing the sugar is essentially a hydrolysis of the mannose polysaccharide contained in the endosperm. Although this method is well known, certain details of procedure required re-investigation with a view to increasing the yields of the product and the experience of eighteen preparations with different samples of meal shows that :—

1. The usually recommended period of 2½ hours' hydrolysis in boiling normal sulphuric acid is insufficient to liberate all the available mannose from its polysaccharide in the meal, while about 10 hours' direct boiling on the wire gauze or 15 hours' digestion in a boiling saturated salt water bath (105°C.) is needed.

2. The amount of destruction of mannose by contact with boiling acid for 10 hours is about 7% but this loss is more than compensated for by the increased yields. There is no deterioration in the concentration of the sugar if the acid solution is kept at room temperature (30°C.) for 2 days.

3. Among different methods of hydrolysis, such as autoclaving, direct boiling on the wire gauze or digestion in a salt water bath, the last method is the safest although somewhat slow.

4. Mannose as obtained in these hydrolyses remains undiminished in strength when kept in a neutralized (*p*H 6-7) sterilized aqueous solution for periods as long as 3 months at temperatures near about 3 °C.

192. Manufacture of hydrogen peroxide by the electrolytic method.

MATA PRASAD, N. R. DAMLE, *and* M. K. CHITRE, Bombay.

Exact conditions for the electrolytic preparation of hydrogen peroxide have been investigated. Ammonium persulphate has been prepared by the electrolysis of a concentrated solution of ammonium sulphate by the chromate method using a current density of 250 amps. per sq. ft. and at various concentrations of H_2SO_4 in the electrolyte. The current efficiency has been found to be 73%. It was found that a preliminary heating of ammonium persulphate with sulphuric acid is necessary to get a fairly good yield of hydrogen peroxide by distillation in vacuum. The optimum temperature, time and concentration of sulphuric acid used

in the preliminary treatment were determined. Under these conditions a solution of ammonium persulphate in sulphuric acid is prepared and distilled under vacuum. The yield has been found to be 80% of the theoretical amount of hydrogen peroxide. Potassium persulphate under similar conditions has been found to give a yield of 84%.

193. Activation of Fuller's earth.

B. S. KULKARNI *and* S. K. K. JATKAR, Bangalore.

A comparative study of the activation of Fuller's earth by treatment with hydrochloric and sulphuric acid showed that for the same concentration and proportion of the acid used, hydrochloric acid gave a slightly better activity than that obtained with sulphuric acid. With both acids, it is found that there is an optimum concentration of the acid required to give highest activity and that this concentration varies with quality of the raw earth. The dry method of activation using sulphuric acid which works cheaper than the wet process, gave products with almost the same activity as those obtained in the wet way.

194. Preparation of activated charcoal for gas masks.

(MISS) NAGAMANI SHAMA RAO, B. S. KULKARNI, L. GOPAL RAO, *and* S. K. K. JATKAR, Bangalore.

Activated charcoal suitable for gas masks has been prepared from charcoal got by destructive distillation of cocoanut shells. The volumetric efficiency of the charcoal has been tested with different concentrations of carbon tetrachloride vapour. A pilot plant has been set up for semi-commercial work.

195. Studies in activated carbons. Part I.

R. N. BHAGVAT *and* Y. V. LAVANDE, Bombay.

Various kinds of activated charcoals are prepared from the indigenous raw materials such as different samples of cow-dung cakes and different varieties of vegetable wastes. These carbons have been studied with regard to their acid and dye adsorption and also the medicinal value of some of these carbons is found by carrying tests with hydrochloric acid and the alkaloids: strychnine, etc. The values obtained are correlated with the ash-content of the charcoals, their porosity and fineness and also structure of the raw material and it is found that the structure of the raw material greatly affects the activation and the degree of adsorbing power.

196. Studies in activated carbons. Part II.

R. N. BHAGVAT, Y. V. LAVANDE, *and* MINOO MEHTA, Bombay.

Activated carbons have been prepared from various raw materials which are industrial wastes using zinc chloride and different gases as activating agents. The raw materials used for the preparation of activated carbon are: maize corn cobs, maize stems, tobacco leaves, and tannin wastes (viz. barks of *Acacia arabica* and *Cassia auriculata*). The active carbons have been evaluated for decolourizing properties by carrying out iodine, benzoic acid and acid and basic dye adsorptions. An attempt is being made to correlate the porosity of these charcoals with the internal structure of the raw materials. The ash-analysis of the unpurified and the purified activated charcoals has been carried out.

197. Studies in activated carbons. Part III.

R. N. Bhagvat, Y. V. Lavande, *and* J. B. Dordi, Bombay.

Activated carbons have been prepared using cow-dung as the raw material and chlorides of the II group elements as the activating agents. The active carbons are then evaluated for their activity by carrying out iodine, benzoic acid and dye adsorptions. An attempt is being made to correlate the activating efficiency of these chlorides with their position in the periodic table. The ash-analysis of the unpurified as well as the activated charcoals has been carried out.

198. Suitability of Indian fireclays for steel ladle brick.

Himansu Kumar Mitra, Jamshedpur.

Refractory brick used in India for lining steel ladles although made of fireclay of high alumina content do not give the same service as some of the bricks made from low grade fireclay in some foreign countries. Service conditions prevalent in a ladle have been discussed. Analyzing the conditions, it was considered that high 'After-Contraction' of the Indian ladle bricks was the cause of the inferior service given by these. Two brands of bricks were specially made with reduced 'After-Contraction' and tried under actual operating condition. Laboratory and service test data on the above two bricks and the brand of brick ordinarily used are given. From these it was apparent that the bricks with low 'After-Contraction' were superior to the commonly used brick. By lining ladles with these specially made brick, it was possible to take more than one and a half times as many casts as taken by ladles with ordinary bricks. Some of the other noticeable features in the former ladles were—(*a*) tightness of joints, (*b*) uniform wear of bricks and absence of pronounced attack at the joints, (*c*) comparatively less damage by 'skulling', and (*d*) the ease with which such skulls could be removed.

199. Manufacture of silica refractories.

J. L. Sarin *and* K. K. Nijhawan, Lahore.

Silica, quartzite and other siliceous rocks were collected from all over Northern India and examined for their suitability in the manufacture of silica bricks. Silica bricks are finding ever increasing use in Northern India with the starting of a number of electric iron scrap smelting furnaces. It has been found that quartzite rocks collected from Jammu, Chakki and Madhopur (Pathankot) give silica brick of good quality. The silica bricks manufactured have been tested for their various important physical and chemical properties.

The physical properties determined for silica bricks from Jammu quartzite are apparent density 2·455; true density 2·3675; porosity 23·14%; P.C.E. (Softening point) 1675°C. (cone 31); Reheat test (after expansion at 1500°C.) 0·66%; Cold crushing strength 483 lb./sq. in.

Constants for silica brick from Jammu quartzite:

Quartz 4 mesh	..	..	..	1¼ lb.
Quartz 8 mesh	..	..	..	1¾ lb.
Quartz 100 mesh	..	..	..	1½ lb.
Fireclay	..	..	..	½ lb. (10%.)

200. Silver staining of glass.

Rama Charan *and* Harirao J. Arnikar, Benares.

Glass is stained a beautiful yellow colour by the application and burning of certain silver salts such as silver chloride or sulphate. The

salt is mixed intimately with an inert material such as red ochre and made into a paste with some water and then applied to the glass surface. When the paste is dry the glass is put into a muffle furnace and heated to a definite temperature usually below the softening point of glass. The glass is kept in a muffle for a definite length of time and is then taken out, cooled and then the paste is washed off and the glass is found to be stained a deep yellow. The actual tint, and intensity of the stain depends on the nature of the glass, the nature and amount of silver salt and the composition of the paste, time of burning and the temperature of the muffle. The usual difficulty in the uniform application of the paste is overcome by the use of colloidal ferric hydroxide and the silver salt. Effect of addition of foreign substances also has been systematically studied and certain generalizations arrived at.

201. Ammonium chloride from town refuse.

J. L. Sarin *and* R. L. Saigal, Lahore.

Town refuse, consisting mostly of dung of various animals such as donkey, cow, buffalo, camel, goat, etc., is collected in the district of Karnal (Punjab). This yields on burning crude ammonium chloride. The refuse is burnt in old type of brick kilns, when the issuing fumes are deposited on the cooler side (exposed to air) of the bricks. This is now scraped and collected by the potters. It was found that when lixiviated with water and concentrated, crystals can be separated by centrifuging. Further purification is done by sublimation. Ammonium chloride produced is quite pure and competes in price with the foreign material. The process of preparation has been demonstrated in the locality and a factory has come into existence.

202. Crude potassium carbonate from wood ash.

J. L. Sarin *and* Narindar Singh, Lahore.

The extent of wood waste and undergrowth available from different Punjab forests was ascertained and the ashes obtained by burning them *in situ* were examined for their potassium carbonate contents. It has been found that from the ashes of *Cedrus deodara* (deodar) and *Butea frondosa* (dhak) wood, 6 to 7% and 10% of potassium carbonate can be extracted, respectively. The process of extraction has been demonstrated in a number of villages in the Simla and Karnal districts. The product that has been produced as a result thereof finds application in local Carbonic Acid Gas factories for refining the gas.

203. Artificial manganese dioxide.

N. S. Saigal *and* S. K. K. Jatkar, Bangalore.

A process for preparing artificial manganese dioxide along with potassium permanganate has been worked out. Samples of the manganese dioxide have been tested by the Indian Research Bureau for the manufacture of dry cells.

204. Treatment of manganese ore with a view to improve its performance in dry cells.

K. Subba Ramaiah *and* Lal C. Verman, Calcutta.

As a result of intensive investigations, a number of indigenous manganese ores have been located which when used as depolarizers give cells having an output capacity almost equal to that required by the

specifications (3·0 W.H.). In practice it is desirable to exceed this output by at least 20%, for various technical and commercial reasons.

It is known that the addition of about 10% of artificial manganese dioxide to the natural ore considerably improves the depolarization characteristics of the dry cells and increase their output.

Artificial manganese dioxide was prepared in the laboratory as a by-product of the process used for the manufacture of potassium and sodium permanganate from manganese ore. This material, however, did not prove satisfactory. Artificial manganese dioxide samples prepared by similar processes in other laboratories were also tried without such success.

Attention was then directed to the treatment of ore material as a whole, with a view to improve its depolarizing performance. Preliminary experiments involved roasting of manganese ore with caustic soda at about 400–500°C. and washing off the soluble salts with water. Improvement obtained in the output of the cells amounted to about 10% in watt-hour capacity, and about 30% in the duration of discharge. Improvement in duration was comparable with that obtained by the use of imported varieties of artificial manganese dioxide, but the output was somewhat lower. This was due to voltage differences. Though the treatment involved is rather simple and involves very little expense, it is considered desirable that further improvement be made, for which purpose experiments are under way.

205. Studies in the preparation on a semi-large scale of dry cells and allied materials.

HANAMANT K. JOSHI, Benares.

The present paper reports results of series of experiments which were carried out to (i) evaluate some of the chief determinants of the electro-chemical performance of a 'dry cell', (ii) to prepare the carbons needed for such cells and elsewhere from Indian raw materials, and (iii) to develop methods for manufacturing the so-called 'active manganese' required for dry cells and imported annually in increasing and very large amounts.

(i) was investigated from the standpoint of the energy out-put of the dry cells according to the British Standard Specifications. The rôle of the following factors has been investigated: (*a*) composition of the electrolyte, (*b*) composition of the depolarizing mixture, (*c*) addition to the depolarizing mixture of active manganese and hydrated manganese-dioxide.

Experiments under (*a*) made by varying the relative proportions of zinc chloride and ammonium chloride, forming the electrolyte, clearly indicate that the rise of internal resistance of the cell on discharge is greater the higher the quantity of zinc chloride present. Satisfactory results were obtained with the electrolyte containing [illegible]% of $ZnCl_2$. Our results with the addition in small quantities of $CaCl_2$ and $MgCl_2$ to the electrolyte show that the quality of the cell is improved by the addition of $CaCl_2$.

(*b*) An extrusion screw-press has been designed for preparing carbon pencils from finely divided coke with pitch as the binding material. This last is about 50% of the weight of the coke powder. This amount depends on (is reduced) by increasing the extrusion pressure, which gives a denser carbon pencil. Data are obtained for the micro-structures of the carbon pencils after different durations of firing, from their densities (apparent).

Series of experiments were made to find out the optimum composition of the depolarizer by varying, within wide limits, the relative proportions of graphite and pyrolusite. In general, the results were most satisfactory with mixtures containing 3·5 to 4·5 parts of pyrolusite and one part of graphite; this exact ratio, however, depends upon the nature of the

pyrolusite and the graphite used. Amongst a few Indian samples of pyrolusite studied, one supplied by the C.P. Mining Syndicate was found to be satisfactory being comparable to the sample obtained from the German company 'Nicholas Branz'.

Several series of experiments were made to obtain comparative data for the efficiencies of the imported 'active manganese' and the hydrated manganese dioxide in elevating the voltage-time curves. The former would appear to be mainly MnO_2 of a special grain size and structure. It has been synthesized by fairly cheap methods from Indian materials. The active manganese dioxide has been prepared by several methods, which have given satisfactory results both by its performance and its cost of preparation. Results of several experiments carried out with a view to investigate the comparative activating power of different samples of 'active manganese', have revealed that this property depends not so much on the proportion of MnO_2 as its mode of preparation, porosity, fineness, etc. This has led incidently to working out in these laboratories some cheap methods for the preparation of quite a range of manganese compounds from the pyrolusite ore by reducing it to Mn_3O_4, which is $2MnO \cdot MnO_2$, and dissolving it in H_2SO_4 under regulated conditions; this leaves behind MnO_2, as a by-product; it possesses a markedly high activating power and is utilizable as '*active manganese*' in the preparation of dry cells.

206. Electro-synthesis of potassium permanganate from Indian raw materials.

S. S. JOSHI, D. N. SOLANKI, *and* DAMRI SINGH, Benares.

In continuation of the previous work, by Joshi and Chandrakant (*Proc. Ind. Sci. Cong.*, Chem. Sec., 1939, pp. 40-41) a detailed investigation has been made in these laboratories, of the electro-synthesis of potassium permanganate from Indian raw materials. Further work shows that optimum conditions in regard to the yield of permanganate prevailed in the electrolysis of a fused mixture of potassium nitrate and pyrolusite. It is interesting that the possibilities of this process have not been hitherto investigated in the field of permanganate synthesis. The present paper reports data in regard to the influence on the production of permanganate, of the following factors: (i) composition of fused mixture, (ii) C.D. at either of the electrodes, (iii) temperature, (iv) time duration of electrolysis, (v) superimposing A.C. on D.C. producing electrolysis, (vi) ratio of current densities at anode and cathode, and (vii) addition of foreign substances or catalysts.

Experiments under (i), with additions of varying amounts of pyrolusite (2 to 50 gms.) to 50 gms. of potassium nitrate show that the yield increases with the quantity of pyrolusite up to 20 gms. and then diminishes with further amounts. C.D. at the anode and cathode was varied within wide limits but the best yield was obtained for anodic and cathodic C.D.'s of 19·2 and 5·7 amps./dm.^{2} respectively. Our results show that temperature variation (250–600°C.) has much appreciable effect on the yield of permanganate which is too low below 250°C. and above 500°C., the yield falling almost to a zero value at or about 600°C. Superimposing A.C. on the D.C. during the electrolysis considerably improved the yield possibly by lowering the potential across the cell or lowering the oxygen-over-voltage over the anode.

The addition of nearly fifty substances of various types as catalysts were studied and Pd, Pt (black), Cu, Ag_2O, CuO, KIO_3, Ni, Co, $KClO_3$, NiO, ThO_2, TiO_2, BaO_2, PbO_2, $K_2S_2O_8$, etc., were found to be the best in descending order. The rest were found to be less promising while agents like V_2O_5, CeO_2, MgO, CaO and CrO_3 were found to be detrimental or negative catalysts.

The principal product of the electrolysis is potassium manganate, which is converted into the permanganate by oxidation after electrolyzed mass is lixivated with acidified water. Great difficulties were experienced due to the presence of KNO_2 produced during the electrolysis. This exerts a powerful reducing action on the final yield of permanganate. This has been obtained by an appropriate adjustment of (i), (ii), (iv), (vi), and (vii). Results are also reported on the electrolysis of KNO_3 and KNO_2 in the fused condition which are interesting, the reaction having been but scarcely reported in the literature.

207. Production of ammonia through intermediate nitride formation by use of active nitrogen.

S. S. JOSHI *and* M. S. DEEKSHITULU, Benares.

Synthesis with a suitable catalyst directly from the elements, reduction of the nitrogen oxides from ammonium salts, decomposition of organic nitrogenous compounds, bacterial action and hydrolysis of nitrides and amides have been the principal sources of ammonia. Electrolysis of aqueous nitrates and allied materials under certain conditions and subjecting the nitrogen-hydrogen mixtures in different types of electric discharge and of electron bombardments have produced but insignificant yields of ammonia. The same remark applies to the attempts of B. Lewis (*Jour. Amer. Chem. Soc.*, 1928, **50**, 27) in mixing active nitrogen with hydrogen and of J. K. Dixon and W. Steiner (*Z. physikal Chem.*, 1931, (B), **14**, 397) from active hydrogen and nitrogen and especially of the interaction of atomic nitrogen and atomic hydrogen on the surface of a catalyst.

We have found that appreciable quantities of ammonia are formed by first leading for sometime a stream of *heated* activated nitrogen over a catalyst kept at a fairly high temperature (about 350°C.) and followed by a similar stream of heated hydrogen also subjected to intense electric discharge. Ammonia is formed on the catalyst surface and is swept out and collected in a trap cooled by liquid air and estimated.

Very low yields of ammonia were obtained with calcium, cadmium, selenium, silicon, bauxite, graphite, sodium carbonate, sodium tartrate, potassium chromate.

The yields were satisfactory with calcium fluoride, antimony, cobalt, magnesium, aluminium, alumina, arsenic, iron, zinc, tungsten, chromium, sulphur, tin, palladium, lithium carbonate, copper sulphate, iron oxide, calcium carbonate. It was very surprising to note that both calcium and barium sulphates worked very efficiently. It was also found in general, that using the best of those catalysts the hydrogen stream, although heated strongly, gave but very poor yields of ammonia compared with those obtained by using hydrogen subjected to electric discharge. Under latter conditions, only a small amount of the catalyst served without the least deterioration for long periods.

Analytical Chemistry

208. The separation of mercury by extraction with ether.

S. RAJAGOPAL NAIDU *and* C. A. SUBRAHMANYAM, Madras.

A method of separation of mercury from copper, iron and lead from a mixed aqueous solution by extraction with ether as a mercury-pyridine-bromide complex, which is sparingly soluble in water but freely soluble in ether, is described. A new iodimetric method of the determination of mercuric sulphide is also described.

209. A new reagent for the estimation of mercury and copper.

S. J. DAS-GUPTA, Baranagore (Calcutta).

2-Chloro-7-methoxy-5-thiol acridine previously described (Das-Gupta, *J. Indian Chem. Soc.*, 1940, **17**, 244) readily reacts with mercuric and cupric salts. The products are insoluble in water and alcohol. Advantage has been taken of this reaction in finding out a method for the quantitative estimation of various mercuric and cupric salts. Even their organo derivatives may be estimated by this reagent.

In the present paper method and the procedure to be followed in such estimations have been fully described. A comparative result obtained by estimating mercury salts by the sulphide method and copper salts by iodide method have also been recorded, and the advantage of the present method has been discussed.

210. Microchemical investigations of some spotted micas and a new microchemical method for the estimation of ferrous and ferric iron.

JYOTIRMOY DAS-GUPTA *and* P. B. SARKAR, Calcutta.

It has been found that sometimes small black spots occur on some transparent Indian Muscovites of Bihar and Kodarma. Chemical investigations of these tiny specks have been taken up in this present paper. Qualitative micro-analysis revealed the presence of iron and the absence of titanium, etc., in those parts of the micas. From the high paramagnetic nature of these spots as compared with the transparent portions of the mica and the ratio of ferrous to ferric iron as determined by a micro-volumetric method devised and described in this paper it is concluded that the spots consist of magnetites.

In this method standard ceric sulphate $N/100$ and titanium chloride ($N/150$) were used. Two different sets of indicators were used, namely (1) ferrous-*o*-phenanthroline with methylene blue and (2) phenyl anthranilic acid with potassium thiocyanate. The result was excellent. Small quantities of ferrous and ferric iron of the order of 1×10^{-2} milligram can be estimated with an accuracy of nearly 2%. This micromethod is recommended for the estimation of ferrous and ferric iron in minerals such as ilmenites, magnetites, chromites, etc., specially when very small quantities of pure mineral are available.

211. Estimation of zinc in snake venoms by micro-quinaldinate method.

PRIYADARANJAN RÂY, Calcutta.

Percentage of zinc in various types of Indian snake venoms has been determined microchemically by means of sodium quinaldinate. It has been found that the zinc content varies from 0·56% in the case of *Naja Naja* cobra venom to less than 0·02% for *Bungarus Ceruleus* among the colubrides, and from 0·186% in the case of *Echis Carinata* to 0·04% for Russel's Viper among the viperides. In purified neurotoxin and haemolysin fractions of *Naja Naja* cobra venom the zinc percentage is reduced to negligible amount. The results indicate that there is no relationship between the zinc content of the crude venom and its toxicity as was previously assumed by Delezenne. The sensitivity and the reliability of the quinaldinate method for the estimation of minute quantities of zinc in biological materials are thus clearly demonstrated.

212. Study of the hydrolysis of chlorine and a review of methods to estimate chlorine, hydrochloric acid and hypochlorous acid occurring in chlorine water.

G. B. KOLHATKAR *and* U. A. SANT, Poona.

Pure chlorine water of different concentrations was rapidly prepared and the conductivity of each was determined immediately and after a period of three hours. The two values of the conductivity were approximately the same. This indicates that the reaction between chlorine and water is a very rapid one.

Solutions of pure hydrochloric acid and pure hypochlorous acid of known strength were carefully mixed and the conductivity of the mixture was also determined immediately and after a period of three hours. The conductivity of the mixture did not alter with time and further its value was identical with that of chlorine water of the same strength. This shows that the reaction between hydrochloric acid and hypochlorous acid is also a very rapid one.

A number of chemical methods suggested in literature to estimate chlorine, hydrochloric acid and hypochlorous acid occurring together in chlorine water were tested. It was found that they do not enable one to estimate correctly the proportion of these ingredients in chlorine water.

213. A criterion for the purity of bromine.

S. V. ANANTAKRISHNAN, Annamalainagar.

A criterion for the purity of bromine based on the definite induction period associated with the uncatalyzed addition reaction with olefines in acetic acid is described. The method adopted for preparing of such purity is also described.

214. Estimation of thiocyanate by ceric sulphate.

M. K. THOMAS, Bangalore.

It is known that in the permanganate method for estimation of thiocyanate only about 95% of the theoretical amount of permanganate is consumed. It was, therefore, considered desirable to study quantitatively the oxidation of thiocyanate by ceric sulphate. Oxidation was carried out in solutions of varying concentrations. The results showed that in no case was oxidation complete, but that it stopped at a definite stage, viz., about 95% of the theoretical. Details of the experimental conditions and the results obtained are presented in the paper.

215. Estimation and hydrogenation of some carbonyl compounds.

M. JAGANNATHA RAO, Bangalore.

The method of Ardagh and Williams for the estimation of ketonic compounds using excess of phenyl hydrazine and back titration of the excess with iodine is tried in the case of the compounds benzoyl formic ester, phenyl pyruvic acid and methyl ethyl ketone. With individual modifications in the procedure the method is successfully worked out in all the three cases.

These compounds are then hydrogenated using platinum and palladium catalysts at room temperature and pressures ranging from 60 to 100 lbs. per square inch. The conversion is calculated by estimating the product according to the above method. About 30–40% conversion is noticed in the case of phenyl pyruvic acid and methyl ethyl ketone.

Further experiments are being conducted at higher temperatures to increase the conversion.

216. The estimation of cystine by nitroprusside.

T. K. Krishnaswamy, Madras.

A simple colorimetric method for the estimation of cystine in protein hydrolysates and enzymic digests has been worked out based upon the colour produced with sodium nitroprusside. The cystine is reduced to cysteine by sodium cyanide and colour developed with sodium nitroprusside in ammoniacal solution in the presence of zinc sulphate. The latter serves to stabilize the colour which otherwise begins to fade in two or three minutes. Proportionality between cystine concentration and intensity of colour exists over a wide range, viz., from 0·5 to 6 mg. of cystine. The method is subject to the usual limitations of colorimetric procedures. However, it is more specific than the Folin-Marenzi method for cystine, while it is much simpler both in respect to procedure and reagents than the Sullivan method.

217. On theories of adsorption indicators.

S. G. Chaudhury, Calcutta.

The possible mechanism of the adsorption of indicator ions has been discussed. It has been shown from considerations of solubility and activity that the activity of an adsorption indicator ion, necessary for ideal titration, should be equal to the activity of the anion or cation (of the same sign as the adsorption indicator ion) in the solution formed from equivalent quantities of the precipitants. The concentrations ($10^{-5}N$) of the indicators, methyl violet, fluorescein and bromophenol blue are of the order of the solubility of the precipitates ($AgCl$, Hg_2Cl_2) assuming that in very dilute solutions activities of ions are equal to their concentrations. In the case of eosin, the concentrations differ slightly from the order of the solubility of silver bromide and silver iodide. Considerations, stated above, also limit the range of concentrations where accurate titrations with adsorption indicators are possible.

218. Observations on detection of denaturants in renatured spirit.

K. N. Bagchi *and* A. B. Ghose, Calcutta.

The renaturation, that is, purification of ordinary denatured or methylated spirit for illicit manufacture of alcoholic beverages such as brandy, whisky, etc., has been a source of some loss of Government revenue, particularly in Bengal and the detection of pyridine and other denaturants in such spirits is an important chemico-legal work. Pure pyridine is detected by Hasses' mercuric chloride reagent (Allen) which gives needle-shaped crystals under the microscope. In the course of this investigation certain deviations from the textbook findings were frequently met with. Not only the needle-shaped crystals but also copious amorphous precipitate either as such or mixed with needles were found. As $HgCl_2$ gives an amorphous precipitate with ammonium salts production of a similar precipitate in a known sample of renatured spirit indicates the possibility of contamination with ammonia. Dragendorff's reagent ($BiKI_3$) which gives an orange precipitate with alkaloids and other organic bases but not with ammonia was found to give a similar precipitate with spirits containing pyridine bases and thus the question of contamination with ammonia could be eliminated.

Fractional distillation of commercial pyridine bases which are used as denaturants according to Government of India specifications, gave

four distinct fractions:—(1) Pyridine hydrate—an azeotropic mixture, (2) pure pyridine, (3) picolines, and (4) lutidines (b.p. 150–155°)—the last being partially soluble in water and giving both amorphous and crystalline precipitate with $HgCl_2$. The other fractions give only crystalline precipitate. After further experiments we came to the conclusion that the samples of beverages suspected to contain renatured spirit and giving amorphous precipitate with $HgCl_2$ should also be tested with $BiKI_3$ reagent to eliminate ammonia but the latter is not to be regarded as a confirmatory test when the base is present as a minute trace. It is less sensitive than Hasses' mercuric chloride reagent. Production of needle-shaped crystals with $HgCl_2$ is not therefore the only criterion for pyridine bases. Amorphous precipitate should also be taken into consideration.

219. A rapid method for the determination of barium in solutions.

E. K. Narayanan, Calcutta.

In many biochemical operations, the introduction of sulphuric acid into a medium and its subsequent removal therefrom by baryta, or *vice versa* are important procedures, often time-consuming. In place of the usual process of striking at the point of exact balance by trial and error, it has been found very serviceable to estimate the sulphuric acid in an aliquot part of the liquid by the following quick and at the same time quantitative method.

An aliquot portion of the fluid, usually 2 c.c., is treated in a small centrifuge tube, with small quantities at a time, as in a titration, of a dilute solution of sulphuric acid—(when barium is to be estimated and removed) of known and suitable strength, from a microburette. The precipitate that is formed is every time sedimented in the same tube with the help of a hand centrifuge. The exact quantity of sulphuric acid needed is indicated by the point at which no precipitate forms when a drop of the acid is added to the clear supernatant liquid. Towards the endpoint the barium sulphate is somewhat slow to make its appearance, but this does not present any difficulty. Knowing the titre value of the aliquot, the amount for the whole of the liquid is calculated in terms of a more concentrated acid and this amount advantageously added without unduly diluting the fluid. This technique has been followed with uniform success in preparations of mannose by the sulphuric acid hydrolysis of vegetable ivory-nut meal.

220. Detection of phenol in high dilutions.

Anukul Chandra Sircar, Calcutta.

A solution of phenol with bromine water gives a precipitate of tribromo phenol, and this method is used for the detection of phenol even in a dilution of 1 : 20,000. It has now been found that if to a higher dilution of phenol a drop or two of freshly prepared solution of bromine be added and the mixture kept in a place exposed to light in a day or two a beautiful pink colour develops. In this way phenol can be detected in solution of even up to 1 : 300,000.

Bio-Chemistry

221. Studies on the influence of pyrophosphate on the oxidation of vitamin C.

P. V. Krishnamurthy *and* K. V. Giri, Waltair.

The effect of pyrophosphate on the oxidation of vitamin C by various catalysts was studied. It was found that pyrophosphate exerts protective

action on the oxidation of the vitamin by Cu, Fe, norit, and copper-albumin complex. The enzymic oxidation was, however, very little affected by pyrophosphate. It also exerted protective action against the oxidation of added vitamin C in urine. The bearing of these results on the nature of ascorbic acid oxidase is discussed.

222. Studies in vitamin C oxidation. Part 1. Coexistence of oxidizing and protective factors in plants for vitamin C.

P. V. Krishnamurthy *and* K. V. Giri, Waltair.

The existence of protective mechanism in vegetables, which protect vitamin C from oxidation has been established. The enzyme ascorbic acid oxidase and the protective factor occur together in various vegetables, and a method is described for the separation of the two factors from one another. The protective factor inhibits the copper oxidation, while the enzymic oxidation of the vitamin is not influenced by it. The enzyme and the protective factor are more concentrated in the pericarp of the vegetables. The nature and properties of the protective factor have been investigated.

223. The effect of carotene, vitamins and sterols on the pancreatic digestion of vegetable oils.

F. G. T. Menezes *and* B. N. Banerjee, Bangalore.

Addition of the unsaponifiable fractions from cod liver oil and butterfat, and to a less extent from spinach and cotton seed oil, to edible oils like cocoanut and groundnut oils was found to considerably improve the rate of their hydrolysis by pancreatic lipase. A similar activation was also noticed when these oils were fried with fish rich in vitamin and with fresh spinach leaves. It will be clear from this that the fat-soluble vitamins, carotene and sterols have an activating influence on the pancreatic digestion of most edible vegetable oils.

With a view to make vegetable products approach ghee in nutritive value, most of the refined, deodorized and hydrogenated oil products on the market (e.g., Crisco, Marvo, Dalda, Vanaspati, etc.) are nowadays fortified with vitamins to a greater or less extent. This addition of vitamin (mostly A and D) will thus incidentally counteract, to a certain extent, the impaired digestibility of the oil, consequent on its refining, deodorization and hydrogenation.

224. Influence of various biologically important substances on the oxidation of vitamin C.

K. V. Giri *and* P. V. Krishnamurthy, Waltair.

The effect of various biologically important substances on the catalytic oxidation of vitamin C by $Cu^{\cdot\cdot}$ was studied manometrically by measuring the oxygen uptake in the Warburg apparatus and by titration with the indophenol dye. Among the substances investigated, oxalic acid, xanthine, uric acid, theophylline and creatinine exert powerful protection, while tartaric, citric, malic, maleic, tannic and aspartic acids, and glycine, alanine, asparagine, histamine and pyrogallol exert slight protection against the oxidation of the vitamin. Creatine, theobromine, succinic acid and other compounds investigated exert no protection. The various possible mechanisms underlying the action of these substances on vitamin C oxidation are discussed.

225. Adulterations and constants of ghee.

N. V. V. PARTHASARATHY *and* B. N. BANERJEE, Bangalore.

A critical examination of the grading and purity standards of ghee leaves margin for 15 to 25% adulteration with foreign fats or hydrogenated oils within the maxima and minima limits. In case of specialized oil cake or fat feeding the standards vary, but they do so in a regular way indicating the passage of the oil from the feed to the milkfat. The Ave-Llalamant Test (Baryta test) is helpful but fails in the case of adulteration with groundnut oils or specialized feeding. Phytosterol acetate test is very helpful if carried out carefully. Even 5% adulteration can be detected when the melting point of the 5th or 6th crop of crystals are determined. The unsaponifiable matter is generally associated with a brown sticky mass. The condensate in the R.M. apparatus is wax-like and chokes up the outlet if hydrogenated fat has been used. The suggested compulsory addition of 1% gingelly oil to all hydrogenated fats appear to be the best remedy as even 0·1% of the oil can be detected with well-known colour tests. In the alternative all the physical, chemical and physiological tests alone can be used for the detection of adulteration.

226. Vegetable dyes as antioxidants for oils and fats.

T. S. RAMASWAMY *and* B. N. BANERJEE, Bangalore.

A number of substances are in use as antioxidants but many of them are toxic and are useless for edible oils and fats.

The antioxidant properties of turmeric and annatto were investigated. While turmeric acted as an antioxidant, annatto was found to behave as a pro-oxidant. As Kamala dye has been found to be an efficient antioxidant for ghee, its study has been extended to fish liver and vegetable oils.

Kamala dye retards the formation of peroxides and the deterioration of vitamin A in fish liver oils. It is also effective in the case of cocoanut, groundnut, cotton seed and sesame oils. Both crude as well as refined oils are protected against early development of rancidity when about 0·1% Kamala dye is added to the oils.

227. Studies on the vitamin content of mangoes. III.

G. B. RAMASARMA *and* B. N. BANERJEE, Bangalore.

In continuation of the work on the factors affecting the vitamin content of the mango fruit (*Agric. & Livestock in India*, 1938, 8, 253; *Jour. of the Indian Institute of Science*, 1940, **23A**, Part I, 1) it has been observed that the ascorbic acid content of mangoes from the same tree varies according to the size; the smaller mangoes having a higher concentration than the larger ones. Maturity at the time of plucking appears to exert a marked influence on the carotene and ascorbic acid content of the ripening mango. The chemical changes taking place in the ripening mango are slower in the prematurely plucked mango, the formation of carotene and sugars is much less and the ascorbic acid content shows a steady fall. The development of carotene and sugars is highest in the mature mangoes and it takes place in a shorter time; the acid content decreases rapidly and the fall in the ascorbic acid content during ripening is less.

228. Studies in sterols. I. Sterol of the mango fruit.

G. B. RAMASARMA *and* P. L. NARASIMHA RAO, Bangalore.

The unsaponifiable fraction from the alcohol-petrol extracts of the pulp of the Badami mango fruit yields after removal of the carotenoid

pigments, fractional crystallization, and chromoatographic analysis, a sterol m.p. 137°C. the nature of which is being ascertained.

229. Enzymatic estimation of tyrosine.

S. L. VENKITESWARAN *and* M. SREENIVASAYA, Bangalore.

A procedure for the estimation of small amounts of tyrosine involving the use of tyrosinase, has been standardized. The oxidation of tyrosine by tyrosinase unlike that of phenol and *p*-cresol, does not proceed with a linear rate of O_2 uptake. Under certain conditions, the total O_2 uptake can be taken as a measure of the amount of tyrosine in the solution. The oxidation consists of two stages, a rapid uptake of 3 atoms of O_2 per molecule of tyrosine taking place in the first 15 to 30 minutes, followed by a very much slower rate of oxidation involving a further 2-3 atoms of oxygen. The two stages are sharply differentiated and under conditions of a large proportion of the enzyme to substrate, the total O_2 uptake during the first half hour of oxidation, is a convenient measure of amount of tyrosine (from 0·1 to 1 mgm.) in the solution with an accuracy of 5 to 8%.

This method is of particular interest because not only 'free' tyrosine, but also tyrosine bound as peptide under a wide range of conditions, is capable of oxidation by the enzyme. All that is necessary is for the phenolic hydroxyl group to be free, with a degree of mobility for its neighbouring hydrogen atom.

Thus, our method is a measure of the tyrosine with its hydroxyl group free or 'active' and is thus capable of throwing light on the state of combination of tyrosine in a given protein. The method can be of great value in the elucidation of protein structure, and in this connection experiments on the conditions of oxidizability of the tyrosine component of known synthetic peptides, are being worked out.

We have, moreover, employed this method in following up the liberation of tyrosine during peptic and tryptic digestions of casein. The increase in the O_2 uptake is found to be due solely to the oxidation of the tyrosine present in the hydrolysate. It is found that the oxidizable group of tyrosine is liberated almost completely during the first few hours of tryptic digestion and also quite easily by hydrolysis with pepsin. The latter fact is in contrast with the failure to isolate more than a very minute fraction as free tyrosine.

230. Formation of uro-lac and its properties.

P. S. SARMA *and* M. SREENIVASAYA, Bangalore.

The course of the formation of compounds of lac with urea and thiourea has been investigated by isolating the compound in the intermediate stages and determining its optical activity and its nitrogen content. Experimental data reveal the existence of three definite stages through which the compound passes before it reaches the final infusible stage. A physico-chemical study of the intermediate compounds has been made. One of the stages designated as B, is represented by a compound in which urea has entered into stable combination but which retains its solubility in alcohol. This compound gets easily thermo-hardened into the infusible stage C on heating for fifteen minutes in an oven at 120°C.

231. Methods of dehydrating plant tissues for technical purposes.

A. V. VARADARAJA IYENGAR, Bangalore.

The utilization of plant parts in industries is manifold. To mention a few of the outstanding ones, starch from different tubers and roots is

widely employed as sizing materials in textiles, paper manufacture, etc. Different fruits such as citrus and tamarinds are useful in the manufacture of citric and tartaric acids. Different barks are sources for tanning extracts. The different raw materials are to be had in abundance during particular seasons as is the case with sweet potatoes, tamarind fruits, etc. The storage of these seasonal commodities with a view to supplying a factory's annual needs without deterioration is a problem of great magnitude and importance. In addition to this, the transport of the fresh materials over long distances is a highly costly procedure and has perhaps not induced the industrialists in the employment of these useful articles.

The difficulties indicated in the above, are to be overcome, as it has been in the case of *tapioca* by sun drying the sliced tissues, during the particular season. This material serves for the rest of the year, on the West Coast. The disadvantages of this method are many indeed, though least expensive. The application of such air-dried materials for industrial purposes, is far from satisfactory, with reference to the purity of the final product.

A survey of the known methods of dehydrating such perishable plant tissues and the advantages secured through a new process employing cheap chemicals, are discussed.

232. Diastatic enzymes from micro-organisms.

S. Srinivasa Rao *and* B. N. Sastri, Bangalore.

A number of organisms isolated from decomposing starchy materials has been examined for their diastase-producing activity. By a process of sub-culturing on a wheat bran medium, it has been found possible to enhance the diastase secreting activity of a few of these organisms, several fold. This has rendered possible their employment for producing commercial diastase for use both in the textile and pharmaceutical industries.

233. Oxidative inactivation of enzymes.

G. Gopala Rao, Waltair.

The view is emphasized that enzymes contain labile groups which undergo reversible oxidation-reduction. The activity of many enzymes is shown to be determined by reversible oxidation-reduction processes. Evidence is collected to show that easily oxidizable substances either protect the enzymes against oxidation or activate them. Mild oxidizing agents inactivate enzymes, and the inactivation can often be reversed by treatment with reducing substances such as hydrogen sulphide, sodium sulphite, glutathione, etc.

234. Studies on ass milk.

C. P. Ananthakrishnan, Bangalore.

A comprehensive study of the composition of the milk of the ass has been carried out, which comprises of the determination of casein, albumin and globulin, fat, lactose, ash, CaO, P_2O_5 and chloride. Investigation of the various non-protein-nitrogenous constituents have been made and the results are discussed.

Casein was isolated by acid precipitation and its purity established. The nitrogen partition of the casein has been determined by the method of Van Slyke as modified by Plimmer and Rosedale including Damodaran's dicarboxylic acid. Estimations of the dibasic amino acids have been carried out by Tristram's method. The present work also includes the study of the nature and extent of the liberation of phosphorus from casein, by trypsin and pepsin.

Albumin was separated by the fractional precipitation with $(NH_4)_2SO_4$ and the nitrogen distribution is given. Independent colorimetric estimations of tyrosine, tryptophane and cystine of casein and albumin have been carried out, and the results compared with that of the cow's milk proteins. The peptic and tryptic degradation of casein and albumin has been investigated. The milk is found to be richer in vitamin C than cow's milk.

Progress is being made on the assessment of the biological value of the proteins of whole milk, and casein, and on the rennet coagulation.

235. Analysis of the Raspuri and Badami varieties of mango (*Mangifera indica*) grown in Mysore.

C. SRIKANTIA *and* N. L. KANTIENGAR, Mysore.

Analysis of the edible portion of the fruit has been made during the different stages of its development with a view to finding out the changes in moisture content, ash, pH, titratable acidity, the reducing sugars and sucrose.

The values obtained are tabulated to show the differences between the two varieties at different stages. It is particularly of interest to note that the Badami variety contains a greater percentage of minerals and less of the sugars than the Raspuri.

236. Investigation on phosphatase from germinating Bengal gram and from bone.

K. P. BASU *and* B. GUPTA, Dacca.

A systematic and comparative study of the phosphatase from two sources has been carried out. The investigation included extraction, purification, determination of pH optimum and of heat inactivation of the enzymes and kinetics of phosphatolysis including effect of substrate and enzyme concentration and estimation of energy of activation of the hydrolysis. Cataphoretic speed of the enzyme preparations has been measured by means of the ultramicroscope. An exhaustive investigation has been carried out regarding the effect of Ca, Mg and Mn salts, of the different amino acids, of ascorbic acid and of glutathione on the activity of the enzymes. From the investigations on the activating action of calcium and magnesium salts on bone phosphatase, a quantitative method for the separation of calcium and magnesium has been developed.

237. Rôle of flavin, phosphorus and hormones in the utilization of proteins.

K. P. BASU *and* H. P. NATH, Dacca.

Partial or complete removal of phosphorus from the diet has practically no effect on the digestibility of proteins. But when it comes to the question of utilization of absorbed amino acids for making good the wear and tear of tissue proteins and for protein formation, phosphorus appears to play a very important rôle. When the amount of phosphate in the diet is low, the biological value of both casein and egg albumin falls appreciably and when inorganic phosphorus is completely withdrawn it falls still further.

Withdrawal of flavin from the diet affects both the digestibility and biological value of proteins. The digestibility is not lowered to the same extent as the biological value.

Administration of adrenaline chloride or thyroid gland preparation or of anterior pituitary preparation, while not appreciably affecting the digestibility of casein, very much lowers the biological value. The effect

is more marked in the case of the administration of thyroid gland preparation and adrenaline than in the case of the anterior pituitary preparation.

238. Observations on the respiratory metabolism of tissues in the presence of plasmoquine.

B. K. NANDI, Bombay.

Plasmoquine has been found at certain concentrations to stimulate the respiration of normal guinea-pig liver, spleen, brain, defibrinated blood and cell-free liver extract, as measured by the Barcroft manometer. Generally three different concentrations of plasmoquinine, e.g. 1 in 6,000, 1 in 15,000 and 1 in 150,000 have been investigated in the case of tissues. A fourth concentration, e.g. 1 in 300,000 has in addition been taken in the case of blood.

The stimulation of oxygen uptake has been most prominent in the case of blood. At 1 in 6,000 concentration of plasmoquinine, the co-efficient of respiratory stimulation has been in one case 1436% the most remarkable feature being that even at a concentration of 1 in 300,000 of plasmoquinine which is usually the level reached by the drug in blood when given in therapeutic doses, the coefficient of stimulation is 41%.

The stimulatory effect of plasmoquinine in tissues, blood and cell-free liver extract is abolished almost to the same extent as normal respiration by the action of heat or cyanide. A general relationship exists in the point that tissues which destroy the least amount of plasmoquinine suffers the highest respiratory stimulation and *vice versa*.

It has been established that the phenomenon of the stimulation of oxygen uptake by tissues, blood and cell-free liver extract in the presence of plasmoquinine is definitely an enzymatic (thermo-labile) reaction, whilst the decomposition of plasmoquinine is mainly through thermo-stable systems present in the tissues.

SECTION OF GEOLOGY

President :—M. R. SAHNI, M.A., PH.D. D.SC., D.I.C.

Stratigraphy and Palaeontology

1. *Psygmophyllum haydeni* Seward from a new locality in Kashmir.

R. V. SITHOLEY, Lucknow.

Some leaves of *Psygmophyllum* identifiable with Prof. Seward's *P. haydeni* have been described from Dandlutar in the Pir Panjai range in Kashmir. The fossils were collected by Mr. D. N. Wadia, lately of the Geological Survey of India. It has been possible to reconstruct from several fragments a shoot on which several leaves with long petioles were attached. In one of the leaves a long petiole is preserved. Another specimen shows the petiole attached to a broad axis by a decurrent base.

The only other part of Gondwana Land from where the genus *Psygmophyllum* has been recorded is South Africa. The widespread occurrence of a characteristically northern genus like *Psygmophyllum* in the Gondwana province is significant.

2. Some Triassic plant remains from the Salt Range in the Punjab.

R. V. SITHOLEY, Lucknow.

Some years ago Mr. E. R. Gee of the Geological Survey of India collected a number of pieces of shale bearing plant impressions from the top of the Triassic sequence in the Salt Range. The impressions are extremely fragmentary and their specific, and sometimes even the generic, identification is very difficult. Mass maceration of the shales has, however, yielded a surprising variety of spores and also a few cuticles. The spores are quite large (in some cases easily detectable by the naked eye) and are mostly preserved as casts, with the cuticle forming a thin covering. The tri-radiate mark (or ridge) is very prominent in many of these spores. In one of the plant impressions, besides a number of sphenopteroid leaves borne on an axis, are seen in one or two places what appear to be epaulette-shaped sori similar to those found in some of the Pteridosperms. Maceration of a little scraping from the region of sporangia-like structures in this specimen has yielded a mass of crushed thin-walled spores.

Petrology and Mineralogy

3. Heavy mineral study of Mylliem granite, Khasi Hills, Assam.

N. N. CHATTERJEE, Calcutta.

On a previous occasion the author gave an account of the granite exposure round about Mylliem and Laitlyngkot together with its important structural features. Granite specimens from the above-mentioned localities were crushed, cleaned and subjected to heavy mineral separation by bromoform treatment. The heavy minerals thus separated from the several specimens are 2·54%, 3·7% and 0·6% respectively. The last one

is from a locality where the granite is more pegmatitic. The chief heavy minerals identified were:—Biotite, iron oxide, zircon, muscovite, epidote, chlorite, pyrite, kyanite, rutile, etc.

In the northern region iron oxide (magnetite granules and crystals) occurs in large quantity whereas in the southern region near Laitlyngkot it is very much less. Biotite on the other hand predominates in the Laitlyngkot granite and is less prevalent in the specimens of the northern area. Biotite flakes appear to be of dirty brown colour showing faint pleochroism and contain granules and crystals of zircon as frequent inclusions around which sometimes faint pleochroic haloes are observed. Sphene occurs in light as well as deep shades of pink and several of them show good crystal outline. Zircon of both colourless and faint pink variety and sometimes with crystal shape recognized. Few crystals of rutile are present.

Detailed description of the minerals is given in the paper.

4. A note on the geology of Dhubri, Assam.

N. N. CHATTERJEE, Calcutta.

The rocks of the Dhubri ridge consist of the following:—

1. Quartz veins both light and dark coloured.
2. Pegmatites, aplites, felspar-epidote veins and microgranites.
3. Pink gneisses both medium grained and very coarse grained.
4. Hornblende schist, quartz-chlorite schist, mica-schist.

The schistose rocks are folded and a gradual change in strike of foliation is clearly seen at some places. Of these rocks the mica-schists appear to be the oldest of the series. The foliations are perfect and in some cases augen structure preserved. The pink gneisses form the chief rock type and occupy a greater portion of the ridge. Mica-schists as lenticular patches and thin sheets are found as inclusions in the gneisses showing the intrusive nature of these gneisses. Mica-schists are traversed by granite pegmatite in *lit-par-lit* manner. Pegmatites and quartz veins, etc., are found to traverse all the other types.

Other characteristic features of the above rock types are given in the paper.

5. Optical, X-ray and magnetic studies of the mineralogical constituents of vredenburgite from different occurrences in India.

S. DEB, Calcutta.

Vredenburgite occurs in Beldongri in C.P. and in Kodur Garividi and Devada regions in the Madras Presidency. This important manganese mineral has been studied since 1928 by W. A. K. Christie, J. Orcel and S. Pavlovitch, H. Schneiderhohn and P. Ramdohr, J. A. Dunn and M. R. A. Iyer and it has been definitely proved that vredenburgite is not a pure mineral species but a mixture of two different minerals—jacobsite and hausmanite. Optical character and reflecting powers of these two mineralogical constituents of Indian vredenburgite have been compared to the jacobsite from Jakobsberg, Sweden, and hausmanite from Thuringerwald, Germany. The reflecting powers have been determined by means of a selenium photoelectric cell, sensitive to red light. The reflecting powers are almost alike.

X-ray diagrams of samples of powder of jacobsite of Sweden and jacobsite constituent of the vredenburgite of India have been determined by the Debye and Scherrer method of powder by means of a gas tube and iron anticathode (λ 1·932A), functioning under 50 K.V. pressure, with a pose of three hours. The two X-ray diagrams are almost identical in character which proves that the two minerals have identical atomic

structures. The magnetic characters on the other hand are quite different. Usually the strong specific permanent magnetism noticed in vredenburgite is due to the mineral jacobsite, hausmanite being non-magnetic. The jacobsite specimen of Sweden on the contrary possesses a weak permanent magnetism. The specific magnetic susceptibility or the coefficient of magnetism in these two different specimens are almost the same. The hausmanite specimen of Thuringerwald does not possess at all the specific permanent magnetism but a slight specific susceptibility has been noticed in this mineral.

6. The relationship of colour to the size of the mineral grain in granophyres and felsites from Mount Girnar, Kathiawar.

A. G. Jhingran, Calcutta.

A study of the relationship between the colour and the size of the mineral grains in granophyres and felsites from Mount Girnar has been made. The textures of the rocks have been examined. The sizes of the microcrystals have been measured and an attempt has been made to establish a mathematical relationship between the size of the crystals and the colour of the rocks. It has been concluded that the smaller the crystals in the groundmass, the darker is the colour; so that a leucocratic rock which is phanerocrystalline has almost a white (or very light) colour and as it becomes microcrystalline the colour changes to darkening shades of grey. With the development of cryptocrystallinity the colour gets still darker. This is in full accord with the jet black colour of obsidian, which is the extreme stage of cryptocrystallinity, the mass being almost entirely glassy.

7. On the probable sedimentary origin of the *quartz-porphyry* occurring to the south of Unchabeda in the Rajgad *mahal* of the Baria State, Gujarat.

A. S. Kalapesi *and* G. S. Awate, Bombay.

Various bands of felspathic quartzites are exposed to the south of Unchabeda, occupying the hill groups Δ 830 and Δ 750, in the Rajgad *mahal* of the Baria State, between lat. 22°31′ and 22°32′ and long. 73°47′5″ and 73°48′5″. These belong to the Rajgad shale group of the Champaner series, and strike in the W.N.W. direction. They have been metamorphosed by the pegmatites belonging to the youngest granite series in the State. Typical high grade metamorphic minerals like sillimanite, garnet, etc., have been developed in them. Some bands of felspathic quartzite show opalescent blue quartz also. These bands are greyish in colour and when weathered their blue quartz and felspars appear more prominently on their weathered surfaces.

A group of porphyry rocks varying from granite-porphyry to quartz-porphyry occurring in different localities and belonging to the oldest granite series of the State has been reported by the senior author who has worked in this area. According to him these porphyry rocks have intruded into the arenaceous and other sediments of this area.

Careful search at the exact locality of the quartz-porphyry previously mentioned shows that the said quartz-porphyry does not differ, in outward appearance and field characters, from the blue quartz-bearing felspathic quartzite.

As many as five specimens representing gradational types of the said quartz-porphyry have been partially analyzed. The typical quartz-porphyry (supposed) yields 81·97% of silica, in close agreement with that of the neighbouring grey quartzite. Heavy accessories from the representative gradational types have also been recorded.

The paper deals with the details noted by us in field as well as in laboratory—microscopic and chemical. From the data obtained the authors are of the opinion that the rock referred as quartz-porphyry by the previous author is probably a metamorphosed blue quartz-bearing felspathic sandstone.

All the chemical analyses were carried out by G. S. Awate.

8. On the age determination of the Deccan Trap basalts of Baria and Amraoti.

A. S. KALAPESI *and* G. S. AWATE, Bombay.

Ten specimens from Baria and six from Amraoti were selected, crushed and analyzed for their uranium, thorium and lead contents. The age of the specimens from Baria was calculated to be 42·23 million years which conforms to the Oligocene period. According to B. Rama Rao, these traps are found to be directly overlying the Lametas.

The basalts of the Amraoti trap, which are dark, compact olivine-basalts, according to the Geological Survey of India, belong to the lowest Deccan Trap series. The 'lead-ratio' results of 91·05 million years confirm well the field observations that the traps date back to the dawn of the Tertiary era.

All the chemical analyses were carried out by G. S. Awate.

9. Microscopic study of some basaltic traps from Amraoti District, Berar, C.P.

A. S. KALAPESI *and* G. S. AWATE, Bombay.

In all five specimens of basaltic traps from different localities in the Amraoti District were examined and found to be all olivine basalts with varying texture. It is interesting to note that the olivine is almost fresh, practically in all the specimens. Felspars occurring in broad laths and plates, range from oligoclase to anorthite. Acid felspars have also been noted in one specimen showing typical flow structure. All the types are highly crystalline with a little or no interstitial glass. The pyroxene is ophitic and mainly augite, but the other varieties showing shades of pinkish brown and bluish grey are also noted. Iron ores, chiefly ilmenite and magnetite, are abundant. One specimen shows dull black glass in hand-specimen, which under microscope appears as cloudy to dusty brown mass, more or less devitrified. Palagonite also occurs in some specimens filling up the amygdular cavities. Only one specimen has been found to be porphyritic.

Small roundish patches of very coarse basaltic rock occur in the compact (comparatively) massive basalt of Vadali hill, Amraoti. Both the types have been partially analyzed by Awate, the silica percentages being 47·41 and 48·43 respectively.

10. Petrology of the Trombay Island (Bombay).

A. S. KALAPESI *and* H. S. DALAL, Bombay.

In this paper the authors have given an account of the igneous rocks of the Trombay Island which lies a few miles east of the Bombay Island and on the longitude (72°55′E) and latitude (19°N). This little island has not been studied hitherto, but the authors put on record for the first time the occurrence of ultrabasic and acid rocks associated with the Deccan Trap lava flows.

The formations show distinct three phases of igneous activity: the Deccan Trap phase, the Ultrabasic phase, and the Acid phase, all of the Tertiary era. The volcanic activity is demonstrated by a host of dykes of basaltic composition and basic tuff (containing beautiful crystals of zeolite) in the trap rocks.

The ultrabasic rock consists of oceanite and ankaramite. This group is full of olivine and pyroxene phenocrysts respectively. The olivine phenocrysts are found either fresh or altered: the alteration being iddingsite. This occurrence of olivine and its alteration product to iddingsite, in the Bombay traps is not common while the acid rock is represented by granophyre.

The authors have prepared a tentative geological map of the island and have shown the field relations, microscopic and megascopic characters of these rocks: also the chemical analysis of each typical rock has been done. The paper is further illustrated by field sketches, microphotographs of the rocks, and a table of chemical analyses.

11. Notes on the occurrence of some organic material in the core of a Deccan Trap rock from a bore-hole at Ananthagiri near Vicarabad in H.E.H. the Nizam's Dominions.

C. MAHADEVAN *and* L. S. KRISHNAMURTHY, Hyderabad (Deccan).

A two feet thick layer of a lustrous dark coal-like material, sandwiched between the Deccan Trap flows was met with during an examination of the cores obtained from the bore-hole at Ananthagiri plateau near Vicarabad. A study of the steep escarpment of this plateau, however, did not disclose any such bed, though the log of the bore-hole correlated intimately with the exposed vertical section in other respects. An analysis of this material gave the following results:—

Moisture and organic matter	6·2%.
Ash	93·8%.

A preliminary examination of the specimen reveals the presence of some fibrous structure.

The paper describes the geological section of the bore-hole, the results of the petrological and chemical examination of the black material, and its probable mode of origin.

12. Origin of some buff coloured siliceous shales occurring in the limestones of the Bhima Series in parts of Gulberga District.

C. MAHADEVAN, Hyderabad (Deccan).

Some buff coloured siliceous shaly layers occur intercalated in the limestones of the Bhima Series near Gogi, Sirwal, Shahbad, Kalgi and Korla in the Gulberga District. King refers to the deposits at Gogi and Shahbad (*Memoirs, G.S.I.*, Vol. XII, pp. 158–160) and assigns them a definite stratigraphic position in the upper Bhima Series and considers them as underlying flaggy limestone beds of Jewargi stage. Recently these deposits have been studied in the field and in the laboratory. They are considered to have been derived from the leaching out of calcium carbonate of the limestone beds by meteoric waters, leaving a skeleton of the more resistant associated aluminous and siliceous materials. The successive stages of the alteration of the limestones to the shaly product can be easily traced in the field.

13. On 'Charnockites'.

P. R. J. NAIDU, Mysore.

This paper gives a petrographic description of the hypersthene-bearing rocks, described as Charnockites, by Sir Thomas Holland and other officers of the Geological Survey of India in some parts of Madras,

Vellore, Salem and Coimbatore Districts, and by Mr. B. Rama Rao in Sivasamudram, Mysore.

Evidence is set forth to show that a granite magma which had been crystallizing in hornblende-ortho-pyroxene phase intruded the areas under study, giving rise to local hybrid phases of small extent, by interaction with pre-existing sediments, schists and gneisses, e.g., the garnetiferous norites (Charnockites) of Nagaramalai, Salem, show evidence of absorption of disintegrated biotite-gneisses; the Charnockites of Kailasgarh, Vellore, are contaminated by amphibolite-schists; and in Pallavaram, Madras, the parallel growth of fibrous hypersthene with a pale amphibole and a concomitant appearance of scapolite, point to contamination by calcareous and aluminous sediments. The Sivasamudram 'Charnockite' is a typical injection gneiss, and does not resemble the 'Charnockites' of Holland, but for the presence of hypersthene in it.

14. A study of the granites and metamorphic rocks of Almora.

S. P. Nautiyal, Benares.

This paper deals with the petrological and petrochemical study of the various granites and metamorphic rocks found near Almora (29° 30′: 79° 40′) in the Kumaon Himalayas. The rocks include schists, quartzites, granites and granite-gneisses.

Many bands of granites are found intruded in a wedge-like fashion parallel to the foliation of the schists. All the bands are entirely gneissose except one which is massive in the centre and gneissose towards the periphery and which gradually merges into the schists without a sharp margin.

The granites bear inclusions of the country rocks which have been partly or wholly granitized.

The foliations in the schist and in the granites are not accompaniments of the same orogenic movement. The schists were foliated prior to the intrusion of the granite. The igneous intrusion has produced a wide garnet zone and tourmalinization of the country rocks. Sillimanite has been observed in certain schists. But the aureole rocks do not show distinct zones of progressive metamorphism.

A number of chemical analyses are also given. The granites have been compared with other granites of the Himalayas.

The problem of the age of the granites is discussed. No precise age can be ascertained but it is definite that the granites are younger than the schists and are pre-tectonic in age.

15. A note on the garnet-biotite-schist from Bhainskhet, Almora.

S. P. Nautiyal, Benares.

During a traverse from Almora to Dwarhat the author came across an exposure of garnet-biotite-schist along the road from Korichhina to a mile ahead of the Bhainskhet Dak-Bungalow. The rock is interesting in showing the porphyroclasts of biotite and garnet, the former showing the development across the planes of schistosity. This paper deals with the petrology and chemical study of the rock.

16. A note on the Tharali granite-gneiss, Garhwal.

S. P. Nautiyal, Benares.

Granite-gneiss is exposed on the Karanprayag-Baijnath road, continuously for a distance of about twelve miles with minor intercalations of slates and schists in between. It has no sharp junction with the schists nor does it contain inclusions. The paper describes the petrology of the gneisses giving their relationship with the similar occurrence at Gwaldam and Almora.

17. A petrochemical study of the Charnockite rocks of Madras.

K. P. RODE *and* C. RAJGOPALAN, Benares.

A collection of rocks from St. Thomas Mount near Madras was studied in detail and about six distinct rock-types could be readily recognized ranging from norite, through granodiorite to granite. These were chemically analyzed and their Niggli-values, basis and norms were calculated and magma types ascertained. The kata-norms were then compared with the modes and a general correspondence was clearly observed. Rocks from widely different regions and having very similar composition have also been compared.

18. Magmatic differentiation in the Charnockite rocks of Madras.

K. P. RODE *and* C. RAJGOPALAN, Benares.

The recognition of several distinct rock-types in the Charnockite complex of St. Thomas Mount near Madras led to a study of the interrelationship and mode of derivation of the different types. The studies on the lines of methods introduced by Niggli proved highly instructive. A complete course of crystallization-differentiation is indicated, the trends being those characteristic of the Calc-alkaline or Circum Pacific Suites.

19. A study of the provincial relationship of the Charnockite series.

K. P. RODE *and* C. RAJGOPALAN, Benares.

During the petrochemical study of the Charnockites of St. Thomas Mount, Madras, it was realized that the Charnockite shows a typical example of the calc-alkaline suites.

The indications as given by the differentiation diagrams based on Niggli-values, the QLM diagram, K-Mg, K-II and Mg-r diagrams all point unmistakably to the same conclusion.

The trends of differentiation observed in the Charnockite magma have been compared with other suites of calc-alkaline character and some very close analogies have been traced in the North American Cordillera.

20. Contributions to the geology and petrology of the Bhowali-Bhim Tal area, near Naini Tal.

K. P. RODE, S. N. VERMA, *and* S. M. MATHUR, Benares.

During the field mapping of the region, particularly the parts covered by the traps, the following rock types were met with more or less in the following sequence:—

Siwaliks.

Traps and intrusives
Schists and phyllites.
Quartzites.

The traps are found to cover a much larger area than was previously known. At certain places the traps are found to be associated with granites and quartz porphyries.

The traps show a certain amount of variation within themselves and the present paper deals with the petrography of the different types.

21. Contribution to the geology and petrology of the Ramgarh Hills near Naini Tal.

K. P. RODE, I. C. PANDE, *and* VISHWANATH PRASAD, Benares.

A preliminary field mapping of an area over 10 sq. miles around Ramgarh Hills, N.E. of Naini Tal, was carried out during the month of May, 1940, and the present observations are based on the collections made during this field work.

The area is chiefly composed of quartzites, schists and foliated quartz porphyries together with a few bands of amphibolites. This note deals with the petrology of these rocks and more particularly of the quartz porphyries.

22. A study of the mineralogy of the Charnockite rocks.

K. P. RODE *and* C. RAJGOPALAN, Benares.

It is well known that the dark mineral-components of these rocks show certain characters which are not quite normal to those mineral species. During a study of the rocks from St. Thomas Mount, Madras, a detailed investigation of the mineral-components of these rocks was carried out the results of which are communicated here.

Hypersthene when studied chemically gave the formula: $5(Al, Fe)_2O_3$, $22(Mg, Fe, Mn)O$, CaO, $33SiO_2$. The mineral is characterized by a peculiar pleochroism, marked oblique extinction and is optically negative with $-2V = 61°$.

Augite shows, roughly, the following composition:—

$$6(Al, Fe)_2O_3,\ 48(Mg, Fe, Mn)O,\ 29CaO,\ Na_2O,\ 77(Si, Ti)O_2.$$

23. Some trends of differentiation in the Deccan Trap.

K. P. RODE, Benares.

On the basis of a large number of chemical analyses of rocks of Deccan Trap region, now available, a partial study of the trends of differentiation in the Deccan Trap magma has been attempted along the lines introduced by Niggli.

Some typical areas have been selected which show a larger range of differentiation products, and from which a sufficient number of rock-analyses are available.

24. Progressive metamorphism in eastern Kalimpong Hills, Darjeeling District, Bengal.

S. RAY, Calcutta.

In the eastern part of the Kalimpong Hills progressive metamorphism is displayed in a series of sericite-chlorite-biotite, muscovite-chlorite-biotite, and muscovite-biotite schists, the progression being marked by—

(i) the gradual increase in size of quartz and felspar grains from 0·1 to 0·7 mm.;
(ii) the gradual disappearance of granulation and sericitization of albite micro-augen present in the lower grades of metamorphism;
(iii) gradual recrystallization of albite micro-augen to medium oligoclase;
(iv) general dominance of chlorite, epidote and clino-zoisite in lower grades;
(v) appearance of garnet in the highest grade of metamorphism.

The lower grade rocks resemble metamorphosed greywacke or medium granite of the 'oligoclase zone', while the highest grade rock is apparently a pelitic schist of the 'garnet zone'.

Garnet also occurs within lower grade rocks where it is either local or marks the beginning of normal 'garnet zone'.

The origin of the chlorite of the lower grades is not determinable correctly. It is doubtfully regarded as secondary after biotite. This indicates a retrogression or derivation of the schists from shearing and metamorphism of a granitic rock.

25. Age of the Kharodiwadi acid trap of Bombay, by the 'lead-ratio' method.

R. N. SUKHESWALA *and* G. S. AWATE, Bombay.

It has been often suggested, on purely field evidences, that the acid traps like the granophyric trachyte, rhyolite, etc., occurring on the west coast of the Salsette Island are younger in age than the main body of basaltic rocks (the Deccan Traps). The authors of the present paper have attempted to find the approximate geological age during which these acid lava of Kharodiwadi were extruded. For this purpose, five different specimens were collected from the well-known Kharodiwadi (lat. 19° 12′E : long. 72° 49′N) acid trap, crushed and mixed together, and the powder analyzed for its uranium, thorium and lead contents. The age deduced by the aid of the 'lead-ratio' method gives a result of 4·28 million years pointing to the Pliocene age of this acid lava flow.

It has been shown by Mathur that the acid traps of Madh and Salsette Fort are in no way magmatically related with each other, and the recent field and analytical data gathered by the present authors also lend support to the above statement. Thus from the data available so far it still remains to be explained whether the acid group of Madh and Salsette belongs to the older or younger horizon than that of Kharodiwadi acid trap.

All chemical analyses were carried out by G. S. Awate.

26. On the correlation of the ash beds occurring in the western parts of Bombay and Salsette Islands, Bombay.

R. N. SUKHESWALA *and* G. S. AWATE, Bombay.

Various types of ash beds of Bombay-Salsette can be classified from their outward characters into three groups as follows:—

(1) Massive, variegated and crumbling variety of Santa Cruz-Khar;
(2) Compact and banded variety of Andheri and Madh;
(3) Thinly laminated pyrite-bearing beds of Jogeshwari.

From the careful field observations and laboratory study, both microscopic and chemical, it can be deduced that the ash beds of Andheri (52·89% silica) and the equivalent type in Madh (54·20% silica) have a common origin. Also, when the silica percentages of the basic traps of Andheri (52·00%) and those of other localities in the area like Malabar Hill (53·12%) are compared with those of the above ash beds we cannot escape the conclusion that the ash deposits of Madh and Andheri are in direct connection with the basic lavas on this west coast. Similarity can still be extended to the acid traps and the ash beds of Madh and Salsette Fort where the silica content (72·70%) of the broad banded ash beds is in close agreement with the silica contents of rhyolites (71·00%) and felsites (71·84%). The Jogeshwari ash shows distinct characteristics of its own in having pyrite-development and the very low silica content of 27·14, but from micro-characters and field study it shows points of resemblance with the acid traps of Kharodiwadi (61·49% silica) and Borivli.

The fact that no magmatic relationship exists between the acid traps of Madh and Salsette Fort and those of Kharodiwadi (Mathur) is further supplemented by the present authors after chemical and microscopical observations. After all this available data the exact sequence of order followed by these different types of ash deposits remains to be elucidated.

General

27. Geological observations on the sub-surface water at Hingoli in Parbhani District of Hyderabad State.

C. MAHADEVAN, Hyderabad (Deccan).

In a paper on the underground water resources in the Deccan Traps (*Jour. Hyd. Geol.*, Vol. II, part 2, pp. 173–194) attention was drawn to the existence of decomposed horizontal layers of basalts which acted as aquifers. Hingoli town, situated in the Deccan Traps, illustrates, par excellence, the importance of geological conditions as well as physiography in the distribution of sub-surface water. The town is divisible into three physical units, i.e. (1) a southern Deccan Trap plateau with well-replenished acquifers at shallow depths, (2) a northern part situated in the valley, but consisting of massive jointed traps to a depth exceeding 100′ which yield little or no water, and (3) an eastern part situated on a similar hard trap, but adjacent to a tank which receives and conserves some of the rain water from the plateau and augments the supply of wells under its influence. The paper gives the geological sequence of the trap layers from a study of the escarpments and bore-hole logs and discusses the distribution of water in relation to geology and physiography in the Deccan Trap formations.

28. The river system of Mysore and its relationship to the geology of the State.

C. S. PICHAMUTHU, Mysore.

The chief characteristic of the drainage of Peninsular India is the marked easterly trend of its main rivers. The water-shed is the Western Ghats which runs almost north-north-west to south-south-east. The paper describes the river system of Mysore, which though part of the Peninsula, possesses certain peculiar features. The water-shed is not parallel to the Western Ghats, situated at the extreme western portion of Mysore as one would expect in Peninsular India in general, but is a line running across the middle of the State almost due west to east, dividing Mysore into two. The rivers take their origin in this middle line and flow either towards the north or to the south.

A brief sketch of the geology of Mysore is then given, and the relationship of the drainage system to the main rock formations is described.

The paper is illustrated by sketch maps and profile sections.

Economic

29. Sulphur in coke and methods of its removal.

N. N. CHATTERJEE, Calcutta.

The author mentions that coke produced from the Tertiary coals of India contains a high percentage of sulphur, and for this reason it is not being used in high class smelting operations. Various methods are discussed by which sulphur may be appreciably reduced: (i) By quenching red hot coke; (ii) by passing hydrogen over red hot coke; (iii) by subsequent quenching the red hot coke from (ii); (iv) by action of volatile

chlorides such as sodium chloride; and (v) ammonium chloride. The author has carried out experiments in the laboratory with two specimens or Tertiary coal, namely (*a*) Namdang coal, and (*b*) watching coal from upper Assam. These coals are of high class coking quality but contain 3·01% and 5·10% total sulphur respectively.

The coal specimens that are carefully selected for laboratory investigation contain only negligible quantity of pyrites but have very high percentage of organic sulphur, i.e. 2·66% and 4·54% respectively. The Namdang coke contains 2·56% and watching coke has 4·11% sulphur.

The author has shown that by quenching red hot coke with water, less than 1%, and by passing hydrogen over red hot coke 40% of sulphur content could be removed. By sodium chloride treatment about 60%, and by ammonium chloride 20% of the sulphur content could be eliminated.

In the first four methods the quality of coke does not deteriorate, whereas in the case of ammonium chloride the coke obtained was loose and friable. The author suggests that experiments in these lines should be carried out on Semi-Industrial Scale in small chamber ovens to find out how far the laboratory methods may be successful in practice, and he therefore draws the attention of the coal producers in Assam and N.W. India to this part of the problem.

30. An outline of the economic geology of the Mayurbhanj State.

B. H. Jena, Mayurbhanj State.

The Mayurbhanj State is very rich in economic mineral resources. Apart from the occurrence of the well-known iron-ore deposits at Gurumahisani, Sulaipat and Badampahar worked by the Tatas, recent geological survey by the Geological Department of the State has led to the discoveries of considerable deposits of vanadiferous magnetite, copper, kyanite, mica, china-clay and glass sand.

Short preliminary accounts of these deposits, other economic minerals and mineral-products and the geological outline of the areas in which they are found, are given in this paper.

Of particular interest is the extensive vanadiferous magnetite deposits along the north-western and south-eastern flanks of the Simlipal range, the latter containing the richest deposits and the former continuing to the north up to Betjharan and Kumardhubi; the occurrence of a mica belt running along a N.E.-S.W. zone to the north of the same range; the occurrence of tourmaline and kyanite-dumortierite along a N.N.W. S.S.E. zone; and lastly, the occurrence of copper ores along a belt nearly in the same line as the tourmaline-kyanite belt.

Architectural and building stones, glass sand of very good quality and clays are also found in the State in quantity.

31. Specific volatile index as a criterion for classifying Indian coals.

C. Forrester, Dhanbad.

In a paper given before the Mining and Geological Institute of India in November, 1939, the author propounded a theory that the calorific value of the volatile matter of a coal may be considered a characteristic of that coal and showed that by arranging the Jharia field coals in the order of this criterion, they were arranged approximately in the order of their rank. He has developed this theory. In the meantime a similar theory has been developed by three Canadian investigators, who use the same criterion in 1932 as a means of classifying Canadian coals. The author now issues a more comprehensive list of Indian coals in the order of their calorific volatile indices and makes various suggestions regarding interpretation of the list as a provisional classification of Indian coals.

32. Study of the ashes of Indian coals.

C. FORRESTER, Dhanbad.

The author surveys the results of investigations of Indian coal ashes by Mazumdar in his own laboratories and those of Dutta-Roy given before the Symposium on coal in India in August, 1939. The question of fusibility is critically examined.

33. Fuller's earth in the Deccan Traps in parts of Chincholi taluq of the Gulberga District of H.E.H. the Nizam's Dominions.

C. MAHADEVAN *and* L. S. KRISHNAMURTHY, Hyderabad (Deccan).

A layer of amygdoloidal trap gives rise in certain favoured localities in parts of Chincholi taluq of Gulberga District to fairly thick beds of a light, porous, groy material which sticks strongly to the tongue. An analysis of a type sample gives the following results:

Loss on ignition	18%.
SiO_2	51·3%.
Al_2O_3	10·0%.
Fe_2O_3	9·2%.
CaO	1·8%.
MgO	9·1%.

The chemical composition and physical properties of this material approximate to 'Fuller's Earth'. The paper describes the mode of occurrence, physical and chemical properties, origin and uses of this decomposed product.

34. Galena in the Nalgonda District, Hyderabad (Deccan).

S. K. MUKHERJEE, Hyderabad (Deccan).

In the last session of the Indian Science Congress in 1940, a paper was read on the occurrence of galena in parts of Nalgonda District as revealed by the prospecting work conducted in that area.

The present paper deals with a few additional observations on the mode of occurrence, origin, nature of concentration, and the associated gangue of the galena ore. The relative age of the quartz-calcite veins in which the galena occurs is also discussed.

The paper is illustrated with block diagrams and photos.

35. Notes on the occurrence of copper ores in the Purana rocks of Nalgonda District, Hyderabad (Deccan).

SYED KAZIM, Hyderabad (Deccan).

To the north of Chintriyal village (lat. 16° 38′; long. 79° 55′) in Nalgonda District copper ores occur in association with quartz veins that cut through the calcareous shales and limestones of the uppermost beds of the Cuddapah formations. An ancient working for copper as well as some megalithic monuments are found in the vicinity. The ores consist of chalcocite and malachite and contain from 36% to 41% of copper. The paper describes the geology, origin and mode of occurrence of the deposits.

36. Kaolin deposits of Chintriyal in Nalgonda District, Hyderabad (Deccan).

SYED KAZIM, Hyderabad (Deccan).

Kaolin occurs interbedded in the calcareous shales and limestones of Cuddapah formation (Kistna beds) to the east of Chintriyal in Nalgonda District.

The limestone and calcareous shale of this area show certain lithological peculiarities; they are of a saccharoidal texture, pearly lustre and are somewhat serpentinous in composition. The kaolin is believed to have been derived by the leaching action of these impure calcareous sediments, the various stages of alterations being observed.

37. A note on the occurrence of Shilajit.

RAJ NATH *and* BRIJESHWAR PRASAD, Benares.

Shilajit was found to occur in Bilaspur State (Punjab) in three formations, viz. Krol Limestone, Nahan Sandstone and Recent Conglomerate. The paper deals with the study of the country rock, the Shilajit and their inter-relationship.

38. A study of touchstones.

RAJ NATH *and* R. S. MITHAL, Benares.

The present paper deals with the chemical and microscopic study of touchstones extensively used in India for determining the quality of gold.

It has been found that the particular property of the stone depends upon the black colour, hardness and the compactness of the rock while the quality depends upon the grain size and the composition.

39. Iron pyrites deposits near Simla.

RAJ NATH *and* R. S. MITHAL, Benares.

In this paper the results of field study of the iron pyrites deposits near Simla, the microscopic study of the country rock and the analysis of the ore are given. The country rock in which the ore occurs is generally chlorite-schist belonging to the Boileauganj quartzite formation. The ore occurs in the form of veins of large width giving an impression almost of sheets which are parallel to the bedding plane of the rocks. The thickness of the ore body is 1 to 2 feet on an average. The deposit appears to contain large reserves.

40. A source of glass sand in Bilaspur State (Punjab).

RAJ NATH *and* M. B. YADAVA, Benares.

The paper deals with the microscopic study, chemical analysis and experiments in glass melts of the sand derived from the white sandstone of Upper Palaeozoic age. The strike of these beds is N.N.E.-S.S.W. They are exposed for several miles along the Bandleki-Dhar. Their thickness is roughly 1,000 ft. The extremely low quantity of dark minerals makes the sand a very suitable material for making glass.

41. Coal from Bilaspur State (Punjab).

RAJ NATH, Benares.

In this paper field observations on the occurrence of coal and the results of a chemical study are given. The coal seam at Dehlag occurs in the Subathu (Eocene) formation. It is about two feet thick, and has got high dips to the east. There are indications on the surface to show that it extends over a sufficiently long distance. The quality of the coal is shown by the following analysis, on moisture-free basis, of a sample of coal from this seam.

Volatile matter	11·00%.
Ash	28·94%.
Fixed Carbon	60·06%.

42. The occurrence and association of phlogopite mica in and about Neyyoor, Eraniel Taluq, Travancore.

V. SUBRAMANYAM, Neyyoor.

The paper deals with phlogopite mica deposits in the area above named, with special reference to (i) occurrence, (ii) types of deposits, (iii) association, (iv) quality, size and colour, (v) by-products. The mica deposits occur in association with pyroxenite dykes as in the case of some similar deposits in Canada. These dykes occur in parallel sheets or bands in the above area with a N.N.E. to S.S.W. strike and a dip to E.S.E. whereas the prevailing rocks of the surrounding country, namely the charnockites and leptynites have a N.N.W. to S.S.E. strike and a dip to the E.N.E. The types of mica deposit met with are (*a*) contact type, (*b*) pocket and fissure type. The pyroxenite dykes consist chiefly of a greyish augite. The important minerals associated with it are albite, felspar and fluor-apatite. Hornblende and anthophyllite have also been noted to occur with it in some places. The occurrence of apatite is noteworthy. The mica is usually of a light amber colour but deeper shades are also not uncommon. Certain schists obtained as by-product are useful for ground mica manufacture. Phlogopite deposits do not seem to occur anywhere else in India.

43. On some aluminous refractories from Sirum, Manbhum District.

H. NANDI, Calcutta.

In several localities around Sirum, Patkum State, Manbhum District, in an area between long. 86° 0′ 0″ to 86° 7′ 30″ and lat. 23° 5′ 0″ to 23° 10′ 0″ kyanite occurs chiefly in association with vein quartz and partially assimilated mica schists, forming quartz-kyanite rocks. The country rock is composed of muscovite-biotite schists intimately penetrated by quartz veins and pegmatites. A staurolite-corundum-kyanite-chlorite rock has been found in one locality near Bandudih. Under the microscope the quartz-kyanite rock shows kyanite, sillimanite, muscovite, rutile, tourmaline and quartz while the latter, in addition to the above, shows staurolite, corundum and chlorite. Muscovite in both the cases and chlorite in the latter are secondary after the aluminous minerals and staurolite respectively. The evidences for elucidating the origin of these rocks are insufficient but they point to the possibility that the kyanite owes its formation to the mineralizing effect of the granite mass in the immediate vicinity.

44. A study of the different forms of sulphur in some Indian coals and lignites.

J. N. MAJUMDAR, Dhanbad.

The work was undertaken to study the forms of occurrence of sulphur in Indian coals and lignites and also to see if any satisfactory explanation of the difference in the colour of ashes could be obtained from the pyritic sulphur content of the coals. The author has analyzed forty-nine samples of coals and lignites collected from different parts of India, and finds that the ashes of many coals which contain less pyritic sulphur are decidedly light buff or brownish in colour whereas those of coals containing more pyritic sulphur are grey or pale grey in colour. There is no striking difference in the percentage of the different forms of sulphur in the Jharia field and Raniganj field coals except that the fixed sulphur of Jharia field coals is higher than that of the Raniganj field coals. The Tertiary coals are highly sulphurous and the mode of distribution of the different sulphur forms in them provides an interesting study.

SECTION OF GEOGRAPHY AND GEODESY

President :—S. M. TAHIR RIZVI, B.A., PH.D., M.A., F.R.G.S., F.R.MET.S.

1. Aboriginies of the Tarai region.

FAKHRUDDIN AHMAD, Aligarh.

The aborigines of the Tarai region have been unduly ignored by the workers on geographical and human aspects of man. Practically all the work dealing with them was carried out in the 19th century by Col. Dalton, Crookes and others who treated the subject from ethnological point of view. Some reference is also found in the District Gazetteers and Census Reports.

Inhabiting the narrow strip of the sub-Himalayan forests extending from the river Sankos in the east to the Jumna in the west, and varying a great deal from tribe to tribe, and from district to district in their mode of living, habits and customs, they deserved attention long before.

The paper is an attempt to describe their human aspect, their mode of agriculture, their small cottage industries, their mode of living and their distribution.

2. The geographic factor in the distribution of wheat in the Panjab.

KAZI SAIEDUDDIN AHMAD, Aligarh.

A study of the general distribution of wheat in the Province and its geographical background.

Wheat regions.

Conditions of growth—soil, climate, rainfall, humidity, cloudiness, temperature, winds and storms. Relation of each of these factors to wheat acreage and yield.

Principal varieties grown and their geographical environment.

Methods of cultivation—rotation, mixtures, ploughing, sowing, spacing, harrowing, irrigation and manuring. Their effect on yield.

Principal pests, their geographical environment and bearing on the acreage and yield.

Marketing and disposal of wheat in relation to communications.

3. The problem of desiccation of the Ghaggar Plain.

SAIYID MUZAFER ALI, Aligarh.

In this paper an attempt is made to investigate the problem of desiccation in an area which occupies the inter-riverain tract between the Jumna and the Sutlej and extends from the Siwaliks to the desert of Northern Bikaner.

The condition of this tract is presented in two strongly contrasting pictures. This area has been in recent times an arid land with a comparatively sparse population. In ancient times the Ghaggar Plain, on the contrary, is represented by various lines of evidence as a fairly densely populated country, well forested and with many populous towns which have either been replaced by small villages or are quite abandoned. The

questions which naturally arise are: (1) Is the contrast between these two pictures so marked and the deterioration of the country so serious as to justify an independent investigation? (2) If so, what are the geographical causes of this change of conditions?

An analysis of facts in this connection brings out clearly that the historical evidence as to the desiccation of the Ghaggar Plain is, on the whole, meagre, varied and controversial. The archaeological evidence as well is ambiguous and misleading. The latter has given rise to many 'working hypotheses' which are wholly unwarranted by facts. Changes of climate supposed to be responsible for the gradual desiccation of the Ghaggar Plain are examined in some detail on the basis of meteorological and historical evidence. It is concluded that there has been no significant change of climate and the explanation for the less favourable conditions during the modern times is to be attributed to causes other than rainfall or climatic changes in general.

This leads to the discussion of various 'theories' which though differing in detail, have agreed in the principle that there have been important hydrographic changes in the present Indo-Gangetic Divide during recent times. In general these arguments lack due consideration of obvious topographic features of the watershed—a fact which can be explained by the absence of good survey maps which were only published during and after the Great War of 1914. On purely physiographic considerations, however, it is established that the alleged desiccation of the Ghaggar Plain during historic times is due to the decrease of the surface and subterranean water and not to any climatic change. The Ghaggar has always been during that period the main drainage channel of the Divide. The diminution of water in this river has been due to :—

(1) direct causes for instance—(*a*) the diversion of a few of its feeders to the Jumna or the Sutlej or both by natural or artificial causes, (*b*) canalization and increasing cultivation in the area, and

(2) to indirect causes as (*a*) deforestation and erosion in the hills in which lie the headwaters of the streams of the Divide, and (*b*) the erosion in the plains due to over-cultivation or excessive pasturage.

4. Fisheries of Bengal.

A. K. BANERJEE, Calcutta.

Bengal is a land of rivers and alluvial lakes, ideal abode of fish of various kinds. Hence Bengal's fisheries contribute very largely to the economic welfare of the province. In this paper some of the Bengal's fisheries are dealt with, which supply fish to Calcutta markets. Various methods for developing the fisheries have also been suggested in this paper.

5. Geographical regions of Bihar.

S. C. CHATTERJEE, Ranchi.

The province of Bihar has been divided into a number of geographical regions based upon relief, structure, land utilization, and the state of economic development. The basis of division and the individualistic characters of each of the regions have been discussed.

6. The Sunderbans of Bengal.

S. P. CHATTERJEE, Calcutta.

The Sunderbans is a deltaic tract, which is being built up by a network of distributaries. Here we find man struggling with Nature for his subsistence and is adopting new technique in reclaiming new lands.

The paper deals mainly with physical features, vegetation, growth of delta and man's adaptation to deltaic environment.

7. Geomorphology of some parts of the Himalayas.

S. P. CHATTERJEE, Calcutta.

It is unfortunate that a geomorphological study of the Himalayas has not been taken seriously by the Indian Geographers.

An attempt has therefore been made to explain the topographical features in terms of underlying structure.

The paper embodies the results of my preliminary investigations of the influence of rocks on topographical features.

8. Incidents in the habitation in Rayalusima.

C. M. RAMACHANDRAN CHETTIAR, Madras.

1. General principles in human habitation—and how they are found generally in South India.
2. Rayalusima and its special features—physical features—spare rains—altitude—health—educational facilities.
3. The nature of the country and the availability of facilities for human habitation—the peculiarity of villages and towns situated mostly near hills and hillocks.
   - i. River banks and their utilization—cultivation—yield—crops—malaria and other diseases,
   - ii. tanks—scarcity and insufficient supply of water—cultivation facilities,
   - iii. hilly ranges and hills—material available for house building,
   - iv. soils of the country—importance of black-soil cotton crop—people who take advantage of the soil,
   - v. trade and industries—sugarcane—cotton—palms and toddy—mat making and other minor industries,
   - vi. minerals—iron—manganese—diamonds,
   - vii. religion and history—growth of villages and towns due to these incidents,
   - viii. means of communication—roads and railways—absence of canals.
4. General conclusions.

9. Market villages and periodic fairs of the Bombay Karnatak.

C. D. DESHPANDE, Dharwar.

Like many other regions, Bombay Karnatak is characterized by a pattern of market villages and periodic fairs. They are the selected 'spots' where the rural community is brought in contact with other regions. In dating and management, these are similar all over Karnatak, but the markets of the Western Karnatak do not function during the monsoons, and on the basis of population, size and economic importance there is a great regional contrast. Periodic fairs are 'specialized' markets claiming a greater and wider commercial allegiance.

Although natural factors exercise a primary influence, it is the human factor, operating indirectly, that determines the pattern of these markets and fairs. In Bombay Karnatak, the indirect influences of economic productivity and the standard of living are more important than means of communications and density of population.

In spite of the rise of commercial towns and development of communications, there has not been any material decline in the importance of these markets and fairs, although they have undergone some changes in

functions, mainly because the exchange needs of the rural community are growing and the commercial towns have not yet fully established their contact with rural areas, so as to render these superfluous.

10. The industries of Mysore.

B. VARADARAJA IYANGAR, Bangalore.

The development and present distribution of industries in Mysore are described in this paper. The beginnings of industrial development towards the end of the 19th century and the great developments in recent years are pointed out, and the changes in the geographical distribution of the industries are also dealt with. The geographical differences between large-scale and cottage industries are distinguished and the factors responsible for the several aspects of Mysore's industrial development are analyzed.

11. The transport system of the Great Moghals—A study in historical geography.

ABRAR HUSAIN KADRI, Aligarh.

In this paper an attempt has been made to discuss the transport system of the Great Moghals. The paper is divided into three parts. In part one internal road system of the Moghals has been discussed at length giving details of geographical, political and financial aspects of the system. In part two the importance of river transport has been described and its organization fully discussed. Part three deals with the Royal Navy and the description of Indian ports used during the period.

12. Fruit industry of the Panjab.

FARHATULLAH KHAN, Lahore.

The paper opens with a discussion on the historical background of the development of gardening during the Hindu and Muslim period.

The geographical factors of soil and climate combined with the artistic taste of the people under the royal patronage of the Moghals introduced a new chapter in the growth of this industry. Modern scientific researches on food value have given a fresh impetus.

The types of fruits and their distribution have been geographically analyzed.

The smallness of acreage under cultivation and difficulties like that of marketing, transport and middle-man's profit are a few salient handicaps under which this industry is suffering.

The paper closes with the future possibilities of development of this industry.

13. The geographic basis of the legendary origin of Kerala.

G. KURIYAN, Madras.

Kerala according to the many legends in vogue has been raised up from the sea by Parasurama. There is a wealth of geological, historical and literary evidence to show that these legends are not to be rejected as puerile.

The plateau laterites of Kerala have in general an elevation of 500′ to 600′ while the valley laterites and the Warkkalay formations are found at a level of 250′. The platoau laterites are the remnants of a plain of marine denudation and the Warkkalay formations are subaquous in origin. Thus the land of Kerala has been vertically lifted up to form

two differing levels, probably in two stages, the latter of which was perhaps during pliocene or post-pliocene times. That there has been a vertical uplift of nearly 250′ is also evidenced by the remains of coral reefs in Vozhappalli and by the marine and estuarine shells found in several parts of Kerala, e.g near Kuttipuli, in borings of the Kallayi river, in the banks of the Beypore river, etc.

During the last glacial period, the sea level became markedly lowered partly by the actual abstraction from the ocean of large quantities of water that were locked up in the polar regions in the form of ice, and partly by the mass attraction of these large ice masses that drew a further quantity of water away from the tropical regions towards the poles. The sum of these factors caused a fall in the level of the sea which is conservatively estimated at 60 to 70 metres, about 250′. It is thus probable that glaciation has been the main cause in bringing to light the regions of laterite and the Warkkalay formations in Kerala.

That the land west of these formations has been lifted up subsequently, is to a certain extent indicated by a study and analysis of the place-names and also by the fact that these traditional legends ascribing miraculous events (although natural in themselves) to superhuman agency are treasured up in human memory.

14. The distribution of population in the city of Madras.

G. Kuriyan, Madras.

In this paper an attempt is made to study the actual distribution of population in the city of Madras from the earliest days up to the present. There has been very little change in the size of the city for the past 200 years and reliable statistical information is available for the last 70 years. The growth of the city has been spasmodic. Its growth is purely due to accretion and is thus dependent on a multitude of extraneous factors. It is also found that the distribution characteristic of the population in the city, has been constant throughout the period 1871 to 1931. As in 1871, so even to-day, it is true to say that Madras is a conurbation being made up of several distinct towns with a loose agglomeration of villages and it possesses extensive and largely undeveloped tracts. In its development, however, there is much to be desired.

15. Ganges valley tube-well scheme.

V. S. Mathur, Ujjain.

The Ganges valley tube-well scheme has proved useful to the cultivators for the winter crops as well as the summer crops.

After a general introduction the Grid scheme has been discussed first and with this as the base it has been tried to discuss the Tube-well scheme.

Whatever gain the various districts have derived has been discussed in the end. The districts involved are those of Bijnor, Moradabad, Budaun, Muzaffarnagar, Meerut, Bulandshahar and Aligarh.

16. Fluctuations of population in a mining centre—the Raniganj coalfield.

D. R. Mitra, Calcutta.

The Raniganj coalfield was one of the earliest deposits to be exploited in India and has therefore supported a dense population, mostly engaged in the coal mines. The paper is an attempt to show the nature of this population—the changes that have taken place in its density and distribution and the geographical and other causes that have brought about this change.

17. Agricultural regions of the United Provinces.

B. N. MUKERJI, Calcutta.

The provinces have been divided in this paper into its agricultural regions based mainly on the crops. The study of factors that are responsible for the cropping have been duly taken into consideration. Wherever relief has been responsible for a particular type of cropping, certain contours have been taken as boundary lines of the above regions. Similarly, where rainfall has been responsible, isohyets have become the boundary lines of the regions. Other factors like irrigation and soil have further helped in clearly defining the boundary lines of the regions into definite sub-regions.

18. The battle of the cities. A geographical study.

B. MUKHERJEE, Lucknow.

The paper makes an analytical enquiry into the competition between Calcutta and Bombay for the position of Urbs prima in India.

The physical life and structure of a city is susceptible of accurate mathematical measurement. But its psychological life—its culture and character, its mind and mood—elude such mathematical treatment.

The following definite and well-known tests are applied to determine relative ranking.

Growth of population: Growth of suburban area: Centrifugal tendencies. Density of population. Cosmopolitan character of the population.

Position of the two ports: Locale; area; shipping and pilotage; Trade served by the ports; Hinterland, Entrepots. The Hooghly; a river of ruined empires and lost capitals; the battle between nature and science: River-training and river-control.

Shipping: Bombay's special advantages over Calcutta: Tonnage entered and cleared in both. Port income and expenditure.

Trade of the two ports; number and importance of trade organizations. Financial positions: Clearing House returns: Reserve Bank shares: Bullion market: Securities market. Minting and Coinage in both centres.

Municipal income; expenditure; civic and municipal amenities; Medical facilities.

Importance as educational centre. Strength of the local judiciary. Importance as Railway centre; control of arterial routes: Air-ports.

Position as intellectual and political centres. Architectural beauties. Position as manufacturing and industrial centres. Social services and civic amenities.

Scope for future expansion and development.

19. Possibilities of augmenting Karachi's water-supply from artesian sources.

M. B. PITHAWALLA, Karachi.

For a long time Karachi—the only city worth its name in Sind—has been suffering for want of sufficient water-supply owing to scanty and variable rainfall (7 inches average). The city has been allowed by the Karachi Municipality to grow, without restrictions, on all sides, the estimated total population being 5,00,000. Only about 10 million gallons per day can be tapped from all the present waterworks, viz. half a dozen shallow wells, a couple of tube-wells, and floating galleries, all lying in the alluvium of the Malir river (a unique system of water-supply in India). The author has now collected some data to prove that another 10 million gallons per day could be secured from some 10 deep borings for artesian wells in the valley at a cost of Rs.25,000 per well. The paper contains a detailed account of an experimental artesian boring directed by him and

carried to 600 feet through Gaj limestones at Dumlottr and now supplying about 30,000 gallons of potable water flowing 8 feet above the surface, for the past four months, thus proving at least semi-artesian condition in the area. The deeper the boring is carried, the better is the supply.

20. Possibilities of developing Sind industries.

M. B. PITHAWALLA, Karachi.

The paper deals with the possibilities of developing the industrial resources of Sind along certain scientific lines. Hitherto the development has been haphazard. A geographical background has been created and a provisional industrial map of Sind has been prepared, showing the localities and the resources which can be organized and developed.

Sind suffers from scarcity of power plants of any kind; there are no chances of water falls except Tando Musti Khan fall (in the Rohri canal, Khairpur State) and no workable coalfields, though a few scanty deposits have been recently noticed in the Kohistan Section. Prospecting for oil has also been suspended due to the war. Suggestions have been made by the author in the present paper for (1) constructing a dam across the Habb and creating a fall a few miles above Hinidan, (2) utilizing solar energy in Upper Sind, and (3) using wind currents for wind mills in Lower Sind.

21. Tuticorin—a town study.

V. TYAGA RAJAN, Madras.

Tuticorin, the largest town in the Tinnevelly district is an important port serving many districts of the southern part of the Madras Presidency. Its growth is due to the hinterland which grows cotton. Population increased with the growth of trade. Several branches of the cotton industry were started. The Municipality reclaimed the town from a sandy and a swampy area and improved it by the provision of water-supply, good drainage and sanitary arrangements. The town was soon rid of epidemic diseases and it grew into a healthy centre. The place is furnished with a net-work of well-laid roads. The people are distributed among the different localities according to their occupation. The Paravans, an ancient race of people living near the sea, are engaged in fishing, diving for chanks and collecting pearl oysters. Though the old-fashioned methods of handling goods have lessened the importance of Tuticorin as a port, it has grown into a first class city and a healthy sea-side resort.

22. Effects of flood-water erosion in the Bhutan frontier in the Brahmaputra valley.

J. N. ROY, Calcutta.

There is a low land at the foot of the Bhutan hills and in the rainy season water comes down in strong currents and cuts a course through the low land as is always the case in the hilly countries. It seems to be a vast sheet of water having strong currents in the rainy season and in other seasons quite dry. It is capricious in nature, its origin and course varying every year.

In this paper attempt has been made to discuss some of the problems relating to erosion by flood-water in this part of the country.

23. Regional distribution and relative growth of the cities of Tamilnad.

N. SUBRAHMANYAM, Madras.

The paper discusses the regional distribution and relative growth of the cities (with population over 50,000) in the Tamil country during the 60 years from 1871 to 1931.

(1) The five cities of class I (with population of over 1,00,000) are shown to be distributed in each of the main historic sub-regions of Tamilnad—Tondaimandalam, Cholanad, Pandyanad (North and South) and Kongunad; and twelve cities of classes I and II (over 50,000) are also evenly distributed in almost all the districts, instead of being bunched together as in the Andhra country.

(2) The outstanding influences on the growth of population in the several cities in each of the six decades are next considered.

(3) The individual and relative growth of the twelve cities during the period is next discussed one by one in order of population of 1931 along with the factors influencing their growth.

A forecast is incidentally made regarding the likely developments in the next census (of 1941).

24. The State tube-well irrigation scheme and its effect on the rural economy of the United Provinces.

MOHAMMAD YOUNUS, Aligarh.

The western districts of the United Provinces have scanty and precarious rainfall and agriculture without artificial water-supply is almost impossible. Here 1,500 tube-wells have been constructed to serve an area of about 2,900 sq. miles.

In spite of the fact that the area under tube-well irrigation is well supplied with gravity canals, still these canals cannot supply the required amount of water, without seriously affecting the supply in the south-western districts of the United Provinces, due to seasonal shortage of water in the rivers. The tube-wells form the most adequate means of water-supply where cheap electric-power is available.

The cheap and certain water-supply from the tube-wells has cheapened and improved the yield of existing crops and has given impetus to the cultivation of more paying cash-crops, such as long-staple cotton and sugarcane, ousting the cheap food-crops.

The tube-well scheme has definitely improved the condition of the cultivator and its benefits to the village have been the best form of the so-called 'rural uplift'. The tube-wells are supplied with transformers from which cheap electricity can be transmitted to small industries such as the village sugar crushers and centrifugals, cotton gins and oil pressing 'Kolhus'. Thus the tube-wells are becoming the real point of rural uplift and the efforts for the betterment and happiness of the cultivator can successfully be made in the area.

The success of the scheme in this region will also help other similar districts where water-supply is uncertain and precarious. On account of a great demand for cash-crops, the cultivators are repeatedly taking out rich crops, which deplete the soil resources. As regards the increased production it must be realized that immediate steps should be taken to check soil exhaustion by encouraging better fertilization of lands and rotation of crops.

25. A résumé of the trends of population and crop production in the United Provinces after 1931.

MOHAMMAD YOUNUS, Aligarh.

In this paper, an attempt has been made to study the growth of population in the United Provinces, after the Census of 1931, in relation to the increase of acreage under crops.

The increase of population in the United Provinces has been much smaller as compared with other parts of India; and the growth of population has been mainly confined to the regions where the agricultural and health conditions have been favourable, yet the struggle for life, it seems, is getting harder, and the low standard of living does not justify any additions to the existing population of the Provinces.

The total crop area has also increased by about one million acres, but the area under food-crops has remained almost stationary, owing to the displacement of cheap food-crops by the more paying cash-crops. Due to the increasing pressure upon land, fresh areas are being brought under plough and there is an increasing practice of double-cropping.

The population is, no doubt, multiplying and the rate of increase may create anxiety, if the means of subsistence do not keep pace with the growth of population. It is evident that the potential increase of the means of subsistence is subject to the real limitations owing to the cultivable land being absolutely limited, while population knows no limits. If we consider the economic condition of the people it may be concluded that the increase of population has out-stripped the means of subsistence. But from a general survey of the economic resources and agricultural and industrial potentialities of the Provinces there is every likelihood of a controversy against our former conclusion, and then, it will still remain to be decided: Are the United Provinces over-populated ?

26. Geographical basis of sugar industry in Bihar.

QAISAR HUSAIN ZAIDI, Aligarh.

The paper begins with a historical survey of the industry showing that Bihar has been well known for the manufacture of sugar since early times and there has been a phenomenal development of the industry after 1932. At present Bihar occupies the second place among the sugar-producing provinces of India.

The geographical distribution of sugarcane crop is studied in relation to the suitability of soil, climate, water-supply and drainage. Adequate rainfall and large quantities of sub-soil water make possible the cultivation of 70% of sugarcane without the help of irrigation.

In view of the variability of rainfall and long dry season succeeding the monsoons experiments are being carried on to evolve drought-resisting varieties for cultivation in non-irrigated areas. Great possibilities of increase in acreage under sugarcane are anticipated on the installation of tube-wells for which a comprehensive scheme is being formulated by the Imperial Council of Agricultural Research.

The importance of sugarcane to cultivator as a cash-crop cannot be exaggerated. It has been responsible for a healthy influence on his outlook and for improving his methods of cultivation. The industry has a great future and with it is vitally connected the prosperity of the peasant class in Bihar.

SECTION OF BOTANY

President :—SHRI RANJAN, M.Sc. (Cantab), DOCTEUR ÈS SCIENCES.

Algae

1. The possible rôle of pyrenoids in algae.

S. R. BOSE, Calcutta.

In most of the chlorophyceae a very faint pinkish stain visible under the oil immersion lens is found in the actual pyrenoids at the centre; according to the recent view (G. W. Smith) pyrenoids synthesize starch, they are not probably *reserve* protein as several pyrenoids are found even in the youngest cells of *Oedogonium* and *Spirogyra*, they are intimately concerned with starch-formation in *Chlorophyceae*. In Diatoms where there is no starch-sheath, Smith has hinted that the pyrenoids possibly function as elaioplasts and may be concerned in the formation of oils, the same faint pinkish stain is found in these pyrenoids. In *Myxophyceae* which have no pyrenoids and where reserve substances are usually glycogen and fat, pinkish vacuoles have been found, usually one in each cell. So probably the pinkish stain constitutes the enzymes which are concerned with syntheses of various food-reserves found in different groups of algae. This pinkish stain is not found in old or disorganized plasmolysed cells. It seems very stable, it does not dissolve in absolute alcohol, acetone, petrol ether, ether, xylol, chloroform, benzol, lactic acid, acetic acid, chromic acid (2%), H_2O_2, caustic potash (2%), or pyridine. With strong KOH (10%) the colour disappears except in the case of *Myxophyceae*. With Wratten filter the colour remains visible. The same pinkish stain has been found by me (*Current Science*, 1939) in vacuoles of growing hyphae of diverse groups of fungi, evidently being connected with the general metabolism of the fungi.

Pyrenoids give protein test with Millon's reagent, by some they are regarded as crystalloidal in character. The enzyme crystals so far obtained are all protein crystals. J. H. Northrop has recently dealt with these crystalline enzymes in his remarkable monograph of 1939 (Columbia Biological Series, No. 12).

2. Revision of marine algae from the coast of Bombay.

KALIPADA BISWAS *and* GOPAL MITRA, Sibpur.

The earliest collection of marine algae was made by Wallich about one hundred and eighteen years ago. W. J. S. Pullen in 1859-1860 gathered some specimens of marine algae from Karachi. J. A. Murray in 1881 made a good collection from the Bombay coast, mainly Karachi. His collections were evidently in several sets. One set is in Kew, another in the British Museum and a third in the Calcutta Herbarium. Murray's specimens along with others have been worked out by Prof. Borgesen who himself with Dixit, Ayenger and Naik collected abundant materials while he was in India from December 1927 to January 1928. He has made a number of contribution on this gathering too. Some of his conclusions on the geographical distribution of Northern algae of the Arabian Sea based on Murray's collection at Kew are erroneous which

Borgesen rectified in his note on a subsequent paper on Bombay marine algae.

The total number of species, varieties and forms of marine algae known to us from the western coast of India is 226, of which twelve species collected by J. A. Murray from Karachi have not yet been recorded from the Arabian Sea, a list of these twelve species is noted. These 226 algae are represented by Myxophyceae—5, Chlorophyceae—52, Phaeophyceae—38, and Florideae—131. Of these again about 17·5% are endemic to Bombay and Sind. The Atlantic or North Western element is represented by 62%, and Malayan or South Eastern element by 66%. Thus the census reveals, as already indicated by previous phycologists, that the Malaysian element is more dominant than the Atlantic. The difference, however, is not very great. This may be due to the geographical position of Bombay and Sind in Eastern Arabian Sea.

A detailed field investigation and a careful study on the different aspects of the marine algae including Diatomales ranging for at least three different seasons are likely to throw light on many important questions such as distribution, nature of the growth and yearly production of the economic species. These data are of considerable value not only to pure researches but also to the important question of utilizing the marine vegetation for many useful purposes.

3. On some phases in the life-history of the terrestrial alga *Fritschiella tuberosa* Iyeng. and its autecology.

RAMA NAGINA SINGH, Benares.

Fritschiella tuberosa Iyeng. has been found growing in 'Usar' land soils of Benares district, especially in a vast tract in Pahari village, which is situated about five miles away from the Benares Hindu University premises. The alga makes its appearance in the beginning of July, soon after first few showers of rain.

The formation of swarmers in the alga has been observed and studied both in the fresh material collected from the field and in plants which have been maintained and obtained under natural cultures in the laboratory. Three kinds of swarmers, the quadriflagellate macrozoospores, the quadriflagellate or biflagellate microzoospores, and biflagellate swarmers representing gametes, like those we find in the genus *Ulothrix* (especially in *U. zonata*), are formed. Swarmer-formation is confined to the prostrate system of the plant. The behaviour of these swarmers has also been studied. The macro- and micro-zoospores germinate directly to give rise to new plants. The gametes (all alike), from different plants, fuse to form the zygotes.

The alga grows under highly alkaline conditions of the soil. The pH ranges from 9·5–11. The E_7 values are found to be between 450 m.V. and 525 m.V. The ammonium-thiocyanate test gives negative results and the diphenylamine test for nitrates appears to be positive though not appreciable. The organic content of the soil is more or less negligible (1-2·3%).

The alga grows at a very low moisture content of the soil. It has been found that the vegetative cells from the different systems of the plant behave differently towards the plasmolyzing solutions of sea-salt. The cells in the prostrate system require highest concentrations.

The evolutionary significance of the alga has been discussed.

4. The rôle of blue-green algae in the reclamation of 'Usar' land.

RAMA NAGINA SINGH, Benares.

During the water-logged period a large number of blue-green algae have been found to grow both under field conditions and in natural

cultures maintained in the laboratory. It has been observed that with the increasing number of these algae the soil conditions change considerably. In the first instance the alkalinity of the soil decreases from *p*H 11·70 to 7·4. The overstanding water, which forms an integral part of the same soil system, behaves similarly with regard to the reaction of the medium. It appears therefore that the injurious salts—the carbonate, sulphate, and chloride of sodium—which make these lands unfit for growing crops, are removed and utilized by these algae. Next, with the decay of some of these algae the organic contents of the soil increases from 1·2% to 4–6%. A fresh crop then comes up and the same cycle is repeated. The oxidation-reduction potential changes from 452–556 m.V. to 320–325 m.V. The ammonium-thiocyanate test gives positive results and the reductivity has the value 3, due to increased microbial activity. The total nitrogen of the soil increases from 0·0082–0·028% to 0·134%. It is concluded therefore that these minute plants can claim to reclaim 'Usar' land soils.

From the above observations a method for reclamation has been suggested, which can be applied by the average Indian farmer.

5. The algal flora and its periodicity in 'Usar' lands of Northern India.

RAMA NAGINA SINGH, Benares.

The algal flora and its periodicity has been studied in Gorakhpur, Azamgarh, Benares and Mirzapur districts of Northern India. It has been found that the algal flora is mainly constituted by the Myxophyceae. It is more or less constant. The first algae to invade such lands are formed by a community, constituted by *Microcoleus chthonoplastes* Thur., *Scytonema ocellatum* Lyngb., and *Phormidium foveolarum* Gom., which appears just after the first three rains. A variant of this has been observed in some of the vast tracts of Benares and Mirzapur districts, where *Fritschiella tuberosa* Iyeng. community with a co-dominant of *Protosiphon botryoides* (Kütz.) Klebs, *Botrydium tuberosum* Iyeng. and *Zygogonium ericetorum* Kütz. grows. In some of the soil samples collected from village Madhopur of the Benares district and kept under cultural conditions in the laboratory, a saprophytic colonial Volvocales, probably a new one, the generic and specific position of which has not been possible to determine, appeared. The next to follow, under increased water-logging, is the *Anabaena* community formed by *Anabaena variabilis* Kütz., *A. torulosa* (Carm.) Lagerh., *Nostoc carneum* Ag., and *Cylindrospermum muscicola* Kütz.

6. The soil complex in relation to zygospore formation and perennation in the desmids.

RAMA NAGINA SINGH, Benares.

The soil complex leading to zygospore formation and perennation, which, as has been described and maintained previously to be a rare phenomenon, in a community of Desmids, growing in small cemented water-reservoirs of the Botanical Garden of the Benares Hindu University, has been studied. It has been found that the reproductive phases occur under highly reducing and acidic conditions of the medium. The *p*H value ranges from 4·8–5·4. The oxidation-reduction potential is 195–333 m.V. The ammonium-thiocyanate test gives the reductivity value as 4. The diphenylamine test shows a negative result. Intense ammonification is observed due to increased microbial activities at temperatures 40–45°C. in the summer months.

The agencies concerned in the distribution of these Desmids within the restricted area of the Botanical Garden, from one water-reservoir to the other has been studied. It has been found that some of these Desmids

do not form zygospores, while in others zygospore-formation is confined only to summer months. They cope with the unfavourable conditions in their shrivelled up vegetative condition. In this state they are able to pass long periods. On the return of favourable conditions the dried up vegetative cells regain fresh growth and activity.

7. On conditions leading to perennation and spore-germination in *Microchaete investiens* Frémy var. *indica* var. nov. and its morphological significance.

RAMA NAGINA SINGH, Benares.

The alga has been obtained growing on ordinary glass slides which have been suspended in the Botanical Garden pond of the Benares Hindu University. It forms a papery deep blue-green stratum on the slides. Some of these slides have been cultured in the laboratory in glass specimen tubes containing pond water. After maintaining the cultures for about a year or so it has been observed that the alga formed spores, which germinated in about a month. The different stages in germination leading to the formation of new plants have been studied. The method of germination has been found to be similar to that described by Fritsch for *Anabaena Azllae* Strasb. During its germling condition the alga could be mistaken for a species of the genus *Calothrix* and it is this behaviour of the alga that aroused interest for its detailed study.

Perennation of the spore and its germination in the alga occurs under extremely inimical conditions of the cultures. The oxygen concentration in the culture solution has been found to be 0·6593 c.c. per litre. The *p*H value ranges from 4·5–5·2. The redox potential varies between 190 m.V. and 220 m.V. The reductivity has been calculated to be 4, and the diphenylamine test is negative. A good deal of ammonification has been found to occur because of the presence of a number of bacteria in the cultures.

The interrelationships of the families Microchaetaceae and Rivulariaceae have been discussed.

8. On a perennial form of *Scytonema* (*S. ocellatum* Lyngb. forma *minor* Bharadwaja), and its autecology.

RAMA NAGINA SINGH, Benares.

The autecology of *Scytonema ocellatum* Lyngb. forma *minor* Bharadwaja, has been studied, especially with respect to its soil requirements. The alga has been found to grow throughout the year and hence it is considered to be a perennial form.

A prolific growth of the alga takes place at a soil moisture of 10–40% of the water-holding capacity of the soil. The oxidation-reduction potential varies between E_7, 359 and 456 m.V., and at higher values (408–456 m.V.) the growth is abundant. The *p*H ranges from 6·2–7·4, and at higher *p*H values the number of individuals of the alga per 0·5 sq. cm. of the soil is more provided the redox potential is fairly high. The ammonium-thiocyanate test shows that the soil samples lack in reductivity. The diphenylamine test for nitrates in the soil shows that the results are positive.

It is concluded that on the whole the alga enjoys a perfectly oxidizing condition of the medium.

9. A systematic account of some diatoms of Karachi.

TARLOK SINGH, Lahore.

Practically no work has so far been done on the marine diatoms in India. In this paper an attempt has been made to give a detailed account of some diatoms collected mainly from the Manora Island, Karachi.

On the whole 51 forms, representing 22 genera, have been described. All these forms are new records for the Indian shore, 5 are new varieties, and 7 new forms.

Fungi

10. Studies on the root-rot of cotton in Sind I.

N. PRASAD, Sakrand (Sind).

1. Isolations were made from rotted material from Sakrand, Shahdadkote, Mirpurkhas and Dadu.
2. Over seven hundred isolates of *Fusarium* and *Rhizoctonia* were obtained and they were grouped in seven different groups.
3. Three types of isolates were found to be parasitic, one of them belongs to the genus *Fusarium* and the other two to *Rhizoctonia*.
4. *Fusarium* and *Rhizoctonia* were found to be more parasitic when together than either of them singly.
5. The morphologic characters of *Fusarium* and *Rhizoctonia* were studied.
6. The *Rhizoctonia* was found to be *Macrophomina phaseoli* (Manbl.) Ashby.

11. Downy mildew of *Setaria verticillata* Beauv.

A. K. MITRA, Allahabad.

Downy mildew (*Sclerospora graminicola* (Sacc.) Schroet) has been observed on *Setaria verticillata* for the first time in India by Prof. J. H. Mitter and the writer. The present paper gives a full description of the fungus on this host as well as the results of inoculation experiments. Only the conidial stage has so far been found. Measurements of conidia and conidiophores under optimum conditions are given. The conidia possess a prominent apical papilla. They are very sensitive to variations of temperature. Beyond 28°C. they fail to form zoospores. A series of stages in the formation of the zoospores has been given.

12. A root-rot disease of *Morus alba* Linn.

T. C. ROY, Calcutta.

Investigations have been made on the root-rot disease of the mulberry plants (*Morus alba* Linn.) as supplied by the Sericulture department, Government of Bengal. Isolations made from the discoloured wood of roots of the infected plants yielded consistently a fungus *Diplodia morina* Syd. Inoculations made with this pathogene on healthy plants were successful. The fungus enters the root and ultimately blocks the xylem cavity of the root causing rot in the roots and a definite shrinkage in the leaf.

The growth behaviour of the pathogene under different temperature, *p*H and conditions of nutrition has been observed. The roots, before and after the inoculation, have been analyzed for sugar (both total and reducing), total nitrogen, total phosphate, Sulphur, Iron, ash and water content and a considerable amount of variation has been noticed.

13. Seasonal distribution and comparative study of five Aspergilli isolated from the atmosphere.

R. C. SALUJA, Lahore.

Presence of species of Aspergillus in different seasons of the year has been studied. Five Aspergilli namely: *A. nigef; A. fumigatus; A. terreus; A. nidulans* and *A. glaucus* have been isolated and studied in culture. The last one is a new find.

14. A study of the Penicillia causing rots of animals and fruits.

R. C. Saluja, Lahore.

Three Penicillia, viz.: *P. expensum; P. citrinum* and *P. digitatum* have been isolated and studied. Growth characters in different media at different temperatures have also been studied.

15. Study of some rusts of the Punjab.

Kartar Singh Thind, Lahore.

Morphological study of 8 rusts on 9 hosts including those on *Asparagus gracilis* and *Grewia asiatica* which were not recorded previously in this country. Teleuto spores of *Uromyces anthyllidis* on *Trigonella faenum-graecum* have also been recorded.

16. Mildews of the Central Punjab.

Kartar Singh Thind, Lahore.

A. 15 species of peronospora causing downy mildews of 25 hosts belong to 7 different families.

B. Some species of Erysiphe causing powdery mildews of 9 different hosts.

17. Cercospora of Lahore.

Kartar Singh Thind, Lahore.

A number of Cercospora species have been collected on 25 hosts distributed over 12 families. The presence of Cercospora on 14 hosts has not been observed previously in this country while on some of these hosts not reported from anywhere.

Gymnosperms

18. A study of the pistillate plants of *Ephedra foliata* Boiss. found at Drigh Road near Karachi in Sind.

B. N. Mulay, Karachi.

1. The morphology of the pistillate plants of *Ephedra foliata* has been studied.
2. It has been observed that the flowering time of these plants is different from that which was previously known. These plants flower throughout the year.
3. Jacket cells have been studied in detail. It has been observed that they may have two, three, or even more nuclei.
4. The cells of the female gametophyte may have a varying number of nuclei.
5. Just a little before fertilization or just a little time after fertilization a nuclear fusion in the gametophyte takes place. From this fusion result cells in which starch is formed in abundance for the nourishment of the young embryo (Trophophyte).
6. Fusion of the jacket nuclei also takes place.
7. The ventral canal nucleus enlarges *pari passu* with the egg nucleus.
8. One sperm nucleus fuses with the ventral canal nucleus. This fusion product is used as the food for the nourishment of the embryo.

19. Chromosome number in *Ephedra foliata* found in Sind.

B. N. Mulay, Karachi.

The chromosome number in *Ephedra* species is now generally believed to be seven or a multiple of seven. In *Ephedra foliata* the chromosome number is also recorded to be seven. However, observations made on the same species found in Sind go to show that the chromosome number found in these plants is definitely more than seven (X).

Angiosperms

20. Conservatism of the vascular system: Comparative anatomy of normal and pentaphyllous Bicarpellary flower of *Gagea fascicularis*.

A. C. Joshi, Benares.

A comparative study has been made of the vascular anatomy of normal and a variant flower with only 5 perianth leaves, 5 stamens and a bicarpellary gynoecium of *Gagea fascicularis* (Liliaceae), which had resulted from the loss of one of the inner perianth leaves and stamens and one carpel. The study shows the total absence of any rudimentary vascular traces for the lost organs. The vascular plan of the flower as a whole, however, is not so affected by the loss, and from the consequent development of asymmetry gives indication of the parts lost. Externally the loss of a perianth leaf and stamen results in the development of a groove on the pedicel.

21. On the morphology and anatomy of the root system in *Asphodelus tenuifolius*.

D. D. Pant, Lucknow.

The root system in *Asphodelus tenuifolius* as described by Professor K. R. Mehta (1934, *J.I.B.S.*, *XIII*, pp. 271–275) and by Professor Sahni (*Curr. Sci.*, *III*, 11, pp. 555–559, 1935) is, so far as we know, unique among the Monocotyledons, if not among the entire group of Angiosperms. Unlike all herbaceous Monocotyledons, here the primary root persists and intracortical roots travel downwards in the cortex of the main root. A periderm is developed round the cortex of the main root and partial periderms are developed on the outer sides of the cortex of some of the intracortical roots.

Professor Sahni had remarked in his paper that the root system of this plant 'deserves a more detailed investigation'. One of the points left in doubt was, how the roots originate and where they begin to bend so as to run downwards through the cortex. The present paper attempts to deal with this question in some detail.

Serial hand sections, both longitudinal and transverse, have been prepared through the cortical region. The material has also been microtomed after softening it in a number of ways.

The roots arise transversely from the vascular tissues of the transition region and then all of a sudden turn vertically downwards almost at right angles. The leaf traces also arise transversely at a slightly higher level but they turn obliquely upwards. A periderm is produced through the activity of a cambium situated along the outer margin of the cortex. On the inner side of the cortex another cambium is present which produces some secondary tissues. Both these cambia arise in the transition region between the stem and root. In the intracortical roots partial periderms are produced at the outer margins which are in contact with the outer periderm as observed by Professor Sahni. In the cortex of the main root some characteristic radially elongated cells of large size are

present which are seen arranged in vertical tiers. The course of the internal roots and the way in which they come out of the main cortex, as well as other details of the anatomy, are described.

22. Origin and nature of the so-called pericycle in the stems of Dicotyledonous plants.

B. C. KUNDU, Calcutta.

The term pericycle was first introduced by Van Tieghem (1882) in describing the sclerenchymatous ring and subjacent parenchyma outside the vascular bundles of Cucurbita stems. Since then the term has been widely in use in describing mainly the sclerenchymatous fibres outside the vascular bundles in Dicotyledonous stems, but it has remained very vague so far its origin is concerned. The so-called 'pericycles' in stems are usually composed of heterogenous tissues. In the roots, however, it is a distinct tissue, usually composed of a single layer of parenchymatous cells and differentiated very early. In many plants, as in most woody stems and in the majority of aquâtic plants and in nearly all Monocots the pericycle seems to be lacking.

Morot (1884) who has made an extensive study on the pericycle, says that the pericycle is of the same origin as the pith and the rays. He has considered the sclerenchymatous fibres of the pericycle as quite foreign to the nature of the phloem. That the pericycle of the stem has always got the same origin as the pith and rays has not been conclusively proved by Morot.

The view points of Morot regarding the origin of the pericycle has been in subsequent years contested by other workers. Léger (1897) has proved from careful developmental studies that the pericycle of the stems is not a distinct tissue, but develop wholly or partly from the protophloem region. Baranetzky (1900) came to the conclusion that even in the Cucurbitaceae part of the sclerenchymatous ring originates from the procambium. Esau (1934, 1938) has furnished definite proof that the fibres of the so-called pericycle develop from the protophloem after the obliteration of the sieve tubes.

The writer's observations in the development of the pericyclic fibres in jute, hemp, Crotalaria, Hibiscus and other plants also support those made by Léger and Esau and have been described in detail.

Though in the early stages of development this tissue is typical protophloem, it later undergoes characteristic differentiation into sclerenchymatous fibres, etc., which are very distinct from the phloem within. Developmentally there is no justification for the use of the term in such cases, but the use of the term is convenient to distinguish the outer zone of stelar tissues which undergoes such characteristic differentiation. In this sense the zone of sclerenchyma fibres which are distributed around the stele in a layer comparatively few cells in depth may be described as pericyclic in contradistinction to the fibres of fibrovascular bundles in such plants as Helianthus.

23. Studies in floral anatomy. V. Gynaeceum constitution in Passiflora sp.

V. PURI, Meerut.

A cursory examination of free-hand sections of the Passion Flower gynaeceum gave me the impression that specialization of the carpels, as has been described by the author in the Moringaceae, also occurs in Passion Flower. A study of serial microtome sections, however, revealed that this was not the case. The carpels here are all of the open valve type fusing margin to margin and developing parietal placentae. Nevertheless, this study lends additional support for my interpretation of the *Moringa* gynaeceum.

24. Development of embryo-sac and endosperm haustoria in *Tetranema mexicana* Benth.

C. V. KRISHNA IYENGAR, Mysore.

The anatropous ovule consists of reduced nucellus and a single thick integument with its innermost layer forming the tapetum. The hypodermal archesporial cell directly gives rise to the linear tetrad of megaspores of which the innermost develops into the normal eight-nucleate embryo-sac. The synergids are large and the egg will be in the neighbourhood of the polar nuclei which fuse when the embryo-sac is mature. The chalazal part of the sac is narrow and contains the three antipodal nuclei. A transversely placed wall which follows the first division of the primary endosperm nucleus separates the micropylar from the chalazal chamber. Subsequent divisions in the micropylar chamber result in four rows of cells of which the four cells towards the micropyle develop into the large aggressive and uni-nucleate micropylar haustoria with processes getting in and digesting the tissue-contents of epistase. The chalazal chamber develops into a nonaggressive haustorium with often one, two or occasionally three or four nuclei, the size of the nuclei being inversely proportional to their number. The endosperm tissue shows smaller cells towards the two ends, with probably a food conducting rôle. Embryo development is normal. The significant enlargement of the tapetal cells during endosperm formation indicates their probable rôle in the digestion and absorption of the integument.

25. The sliding, gliding, symplastic or the instrusive growth of the cambial cells ?

G. P. MAJUMDAR, Calcutta.

The cambial cells characteristically divide by tangential walls. Their division by slightly oblique transverse walls are also known to occur at long intervals, but they are seldom seen to divide by radial walls. How then does a cambial layer widen tangentially, with increased number of cells in cross section, during the secondary growth in thickness of a stem ?

Various theories have been suggested for the solution of this problem. In this paper the author supports the theory of intrusive growth with lantern slides and photomicrographs.

26. Life-history of *Euphorbia helioscopia* Linn.

(MISS) VIMALA BHALLA, Lahore.

Microsporogenesis :—

The haploid number of chromosomes is definitely 21 as observed from the polar view at the anaphase. The hetero- and homo-type divisions are normal. The spore formation is by tetrahedral method. Occasionally only dyads are formed which get liberated from the mother cell-wall. It is not possible to state whether they function normally, although apparently they seem capable of doing so. Vegetative nucleus is cut off before the pollen is shed. Some microspores are observed to degenerate.

Megasporogenesis :—

The tricarpellary pistil contains one anatropus ovule in each loculus. The single hypodermal archesporial cell cuts off an upper parietal cell and a lower megaspore mother cell. The latter gets buried deeply into the nucellus, by the activity of the former. The development of the embryo-sac is as usual.

The polar nuclei remain distinct in the ripe embryo-sac. The antipodals are usually not ephemeral. The endosperm develops by the

free-nuclear division. Suspensor is small and disintegrates as the dermatogen is cut off—when the embryo has reached an advanced stage.

27. Sterility in *Euphorbia Royleana* Boiss.

(MISS) VIMALA BHALLA, Lahore.

Microsporogenesis has been studied and some interesting abnormalities recorded. Laggards during the meiotic division are frequent. In some cases chromosomes are observed scattered all along the spindle. Tetrahedral formation of the microspores is the rule in the species. The microspore is binucleate, when ripe as in *E. helioscopia* and apparently seems to be functional. Chromosomes count could not be accurately made as they frequently appeared jumbled. Counts during diakinesis reveal them to be certainly more than 30.

The archesporial cell, is not hypodermal as in *E. helioscopea* but buried 2-3 layers deep in the nucellus. After this it degenerates. Consequently there is no formation of a female gametophyte and the female flowers shrivel up after some time. This is true both for the species artificially propagated as well as those growing wild. There is thus no seed formation and the species propagate by vegetative method.

28. Note on the chromosome number in double-flowered *Polyanthes tuberosa* Linn.

NARAYAN DATTA, Lahore.

The haploid chromosome is 30 (25 small and 5 large).

At leptotene stage beaded appearance of spireme is clear. Synizesis seems to be an artifact. Bivalents completely condense at diakinesis and the nucleolus still persists. All the divisions are of normal type. Arrangement of tetrads is T-shaped and bilateral or even more or less linear.

29. Life-history of *Nothoscórdum fragrans* Kunth. and the structure of their chromosomes.

NARAYAN DATTA, Lahore.

Microsporogenesis :—

1 to 4 nucleoli are observed in the resting nucleus (Budding of nucleoli in the root tip cells has been noticed). During mitosis the course of ordinary spireme is observed to be discontinuous at early prophase. Diploid chromosome number is 18. All other stages are normal.

The microsporogenesis has been studied. Haploid number of chromosomes is 9, the biggest of which is 20u long. At metaphase 2 chromonemata could easily be distinguished embedded in a matrix. Chromonemata are uniform in their diameter. Tetrad arrangement is bilateral. Usual normal division occurs.

Megasporogenesis :—

Ovary is trilocular with numerous reclining ovules. Upper ones are arthotropous, while the lowermost are compylotropous, arranged on an axile placenta. One or two hypodermal archesporial cells present. Megaspore mother cell divides into 3 megaspores. Lowermost is functional. Further development of embryo-sac is as usual. True polyembryony is present. Embryos are derived from the cells of the nucellus above the apex of the embryo-sac.

30. Cytology and development of female Gametophyte of *Allium* sp.

NARAYAN DATTA, Lahore.

Microsporogenesis :—

Somatic division is normal.

Haploid number of chromosomes is 16. Hetero- and Homo-typic division is quite normal. Tetrads are bilaterally arranged.

Megasporogenesis :—

Ovules 6, arthotropous, 2 in each loculus. Ovules have 2 integuments. Development of embryo-sac is of Adoxa-type. Synergids are beaked. The oospore moves towards the micropolar end. Antipodal cells seem to exert haustorial function on the nucellar cells below.

Physiology and Ecology

31. Succinoxidase in plants.

M. DAMODARAN *and* T. R. VENKATESAN, Madras.

The presence of succinic dehydrogenase in certain seedlings of the Leguminosae was recently demonstrated (M. Damodaran and R. Ramaswamy, *Current Science*, 1940, Vol. 9, No. 7, p. 319). The enzyme has now been further studied and it has been possible to demonstrate the existence of the complete succinoxidase system in plants. Manometric studies show that the oxygen uptake of the system is increased by the addition of cytochrome C, inhibited to the extent of 70–80% by malonate and pyrophosphate and completely inhibited by cyanide. Experiments on the separation of the enzyme system into its several components are in progress.

32. Urea formation in germinating seedlings.

M. DAMODARAN *and* T. R. VENKATESAN, Madras.

In studying amino-acid changes in germinating seedlings it was found that in *Dolichos biflorus* and *Phaseolus mungo* the amide nitrogen exceeded the dicarboxylic amino acids present so that the existence of amides other than asparagine and glutamine was indicated. Further experiment showed that the additional amide was urea. To investigate the origin of this urea, determinations were made of the changes in arginine, urea, arginase and urease content of the two seedlings during germination. The experimental results bear out the conclusion that in *Dolichos biflorus* urea is formed from arginine by the action of arginase while in *Phaseolus mungo* it could not have arisen by this reaction.

33. Effect of light intensity and temperature on the growth of *Azolla filiculoides*.

GHIAS-UD-DIN AHMAD, Lyallpur

1. An experimental technique for the study of the influence of temperature and light intensity upon the growth of Azolla sp. is described.
2. The growth of Azolla sp, in the Hoagland solution was very good, to which no organic matter extract was added.
3. In lower intensities of light, root system showed very poor development, but as illumination was increased, a great improvement in the development of roots was noticed.
4. The light and temperature both acted as limiting factors simultaneously, since an increase in either of these factors favourably influenced the growth of Azolla sp. within a limited range.

5. Increase in the factor which was present in most nearly minimal amount resulted in the most favourable increase.

6. The curves obtained are almost regular and do not show a sharp bend as postulated by Blackman.

7. The importance of the internal factors, time factor, the inter-relationship of the factors and compensation point is emphasized.

8. The practical possibility of the duplication of experimental data is shown.

9. In conclusion the results reported in the paper fully substantiate the previous works of Harder, Lundegardh and Warburg.

34. The growth of *Azolla filiculoides* in mineral solution without addition of 'auximone'.

GHIAS-UD-DIN AHMAD, Lyallpur.

1. *Azolla filiculoides* was grown in the green-house in one litre solution of Hoagland solution with and without addition of yeast and peat extracts.

2. The plants supplied with organic matter extract showed better growth and developed larger size.

3. Next, the plants were grown under controlled conditions of light and temperature in the mineral solution, with and without aquatic extract of yeast, the later showed 8 to 10 per cent more growth in one week.

4. *Azolla filiculoides* was successfully grown in Hoagland solution for four months continuously without any deterioration in the power of its multiplication. The health and growth of the plants remained good, provided light and temperature were not acting as limiting factors.

5. The addition of extracts from yeast and peat improved the growth and size of the plants, but their addition to the mineral solution was not essential for growth.

6. It is now known that yeast extract and some growth promoting hormones have similar constituents of indole acetic acid and certain amino acids, which are excellent growth promoters.

7. It seems probable that *Azolla filiculoides* is capable of producing 'auximone' within itself under suitable conditions of growth.

35. Viability test with paddy variety, Cherunel.

N. K. B. KURUPP, Kayamgulam (Travancore).

The paper deals with the results of Germination Tests conducted in the laboratory with the seeds of Paddy variety Cherunel, with a view to determining the period during which the seeds of the said variety could be stored (in this particular case in glass Jam Jars with screw lids) without impairing their germination capacity. The tests were made at intervals of about 30 days and as a result, it is found that they keep up their normal tone and vitality even for 14 months after harvest. From the 15th month the vitality of the seeds becomes very much lowered till the 22nd month, when all the seeds get decayed instead of germinating.

36. Effect of temperature and time on dry weight determination of mango pulp.

S. M. SIRCAR *and* K. M. SEN, Calcutta.

A method of determining the dry weight of mango pulp was investigated. Temperatures higher than 50°C. were found unsuitable for dry weight determination of mango pulp; at these temperatures constant weights were not obtained on account of the presence of an unknown

volatile constituent. Drying at 50°C. for 24 hours at atmospheric pressure was found to be suitable for dry weight determination of mango pulp.

37. The oxidation-reduction potential of 'Usar' land soils.

RAMA NAGINA SINGH, Benares.

The oxidation-reduction potential of 'Usar' land soils of Northern India in relation to *p*H, amount and states of ions present and organic content has been studied. It has been found that the redox potential ranges from E_7 240–432 m V. and depends more upon the amount and states of ions present in the soil samples than upon any other factor. Most of these measurements have been carried out in the field.

38. Root systems of plants of eroded areas in Hoshiarpur Siwaliks.

P. ANAND, Lahore.

The paper deals with root systems of about 21 plants of a stretch of area in the Siwaliks which includes forest land between Chohal, Mangowal and Nari within a radius of about two miles on both sides of the Hoshiarpur Gagret Road.

It is possible to arrange the rooting systems of plants in a rough series showing a progressive reduction of the typical main root system consisting of tap and laterals in favour of an adventitious system developed on an extensive net-work of root suckers and other adventitious structures arising from them. The following types clearly represent the successive stages of this series: —

Acacia Catechu, *Prosopis spicigera*, *Dodonaea viscosa*, *Zizyphus nummularia*, *Woodfordia floribunda*, *Flacourtia Ramontchi*, *Ficus cunea*, *Carissa spinarum*, *Stereospermum suaveolens*, *Adhatoda vasica*, *Vitex negundo* and *Diospyrus montana*.

The region of maximum water content in the soil and the region of maximum absorption of the root system coincide with each other.

The *p*H value of the soil vary from 6·8 to 8·6. The mechanical analysis shows that the highest percentage is of particles between the sizes of 0·6 to 0·002 mm. There is a uniform distribution of these in the various samples except in *Vitex negundo* which shows an extraordinary high percentage of particles between 0·6 to 0·2 mm, *Acacia Catechu* that has a low percentage of these particles but a high percentage of particles between 0·2 to 0·002 mm and *Dodonaea viscosa* with a very high percentage of very small particles 0·02 to 0·002 mm.

Two types of root systems are most suited to the area under investigation: —

(i) Deeply-seated systems of taps and laterals, supplemented by a superficial mat of fibrous adventitious roots. (ii) An extensive system of root suckers. It is suggested that the following plants may be effectively employed in antierosion and reclamation work: —

Dodonaea viscosa, *Zizyphus nummularia*, *Acacia Catechu*, *Euphorbia royleana*, *Acacia modesta* and *Woodfordia floribunda* out of the plants with a root system of tap and laterals; and *Diospyros montana*, *Carissa spinarum*, *Adhatoda vasica*, *Vitex negundo* and *Flacourtia Ramontchi* from among those that propagate by means of root suckers.

39. Succession in xerophytic grasslands of Raita.

F. R. BHARUCHA *and* R. N. DAVÉ, Bombay.

In this paper the authors have described the succession of vegetation taking place on the grasslands of Raita (Near Kalyan) and shown how

the succession study helps rapid solution of the problem of improvement of grasslands and how it helps in the scientific management of the grassland by the use of synthetic fertilizers. Also the present study helps to evolve a system of rotational grazing within a short time of three years.

40. The biological spectra of Matheran and Mahabaleshwar.

F. R. BHARUCHA *and* (MISS) D. B. FERREIRA, Bombay.

On the basis of Raunkiaer's system of Life-forms, the flora of Matheran and Mahabaleshwar, the two hill stations of the Bombay Presidency were analyzed. These places were particularly chosen for the floristic and climatic data were fully available. Besides they are limited in their boundaries and are similar in their tropical, moist, evergreen vegetation.

The analysis of their flora reveals that both have a Phanerophytic plant-climate which accords well with their climatic features of heavy rain-fall, fairly high but almost constant temperature and little fluctuating relative humidity. Thus the above study proves the statement of Raunkiaer that 'the characteristics of all tropical lands in which the precipitation is not too small, the centre of gravity in the biological spectrum is amongst the Phanerophytes'.

41. The biological spectrum of Madras.

F. R. BHARUCHA *and* (MISS) D. B. FERREIRA, Bombay.

Madras was chosen as another place to test Raunkiaer's theory because it lies on the east coast of India and as such comes under the influence of the north-east monsoon and as such has a totally different type of vegetation from that of Matheran and Mahabaleshwar. Besides recently its flora has been completed and as such its analysis would give very reliable test.

From the biological spectrum of Madras it is found that its climate may be said to Nano-phanerophytic with a high percentage of Chamaephytes. This is an interesting case for its spectrum resembles that of Aden whose climate exhibits conditions on the border regions between the tropical and the subtropical with dry climate.

42. The biological spectrum of a grassland association.

F. R. BHARUCHA *and* R. N. DAVÉ, Bombay.

To test further the theory of Raunkiaer an attempt was made to find out if the biological spectrum of a grassland association could be explained by the chief climatic features of the region, namely, rainfall and temperature which he represented by a figure called the hydrotherm.

The analysis of the floristic composition of this particular grassland association, which is provisionally named the Themeda-Pseudenthistiria Association found on hilly and stony grounds in the Bombay and Salsette Islands, reveals it as an association which is predominantly therophytic or annual. This cannot be explained on its climatic features alone for the region has a heavy rainfall of more than 100″ in. per year. As such the spectrum can only be explained if we take into consideration another factor besides the above climatic ones, namely the biotic. The latter can explain the spectrum as a therophytic one. A similar case has been recorded by Allan in New Zealand.

43. Study of the weeds of the Chilka Lake—I.

P. PARIJA *and* B. PARIJA, Cuttack.

Weeds such as *Potamogeton pectinatus* float up in masses in the lake towards October. Blue green algae like *Lingbya* grow among the floating

weeds and form a matted mass. Mosquito larvae thrive protected by the weed masses and cause malaria. The problem was why the weeds float up. It was necessary to make a systematic study of the weeds throughout the year. *Potamogeton* which is the predominant weed covers extensive areas in shallow water and grows with the rising level of the lake.

The influence of the various ecological factors such as light, hydrogen ion concentration, salinity and turbidity of water and the biotic factor has been studied.

From the data so far gathered it is clear that—

(1) due to turbidity very little light penetrates to the weeds and in consequence the weeds become etiolated and weak;

(2) increasing salinity controls the growth of the weeds;

and (3) young bivalves attach themselves to the weeds and eat into the cortical tissues and thus render the plants weak and liable to be broken off by the waves; the breeding season of the bivalves is the early rains.

SECTION OF ZOOLOGY

President:—A. Subba Rau, B.A., D.Sc., F.R.M.S.

1. Observations on a new amoeba, *Dobellina rayi* n.sp. from *Varanus monitor* Linnaeus.

P. L. Misra, Lucknow.

A new amoeba belonging to the genus *Dobellina* has been recorded for the first time from India. Bishop and Tate (1939) instituted a new genus *Dobellina* found in the dipterous larvae of *Trichocera haemalis* Meig. (the common 'winter gnat') of Europe, and called this species *D. mesnili*. In this paper I have given a detailed morphological account of *Dobellina rayi* n.sp.

The trophozoites (7–21μ; averg. 9·92μ) move actively by means of a blunt pseudopodium consisting of clear ectoplasm. The cytoplasm is differentiated into ectoplasm and endoplasm, the latter being charged with refringent granules, but totally devoid of chromatoid inclusions. Food and contractile vacuoles are absent. Nutrition takes purely by osmosis. The nucleus (4·2–5·6μ in diameter; averg. 4·46μ) is spherical and usually eccentric in position; it is bounded by an achromatic nuclear membrane and consists of a central, spherical, siderophilic karyosome (1·8–2·8μ; averg. 2·3μ) surrounded by a colourless halo. Multinucleate forms have also been encountered, but are rare. Four to eight nucleated cycts (8–11μ) are common, but supernucleate cysts (18–21μ) containing 16–32 nuclei have also been observed. The wall of the cyst is thin and delicate and is single.

It is also interesting to note that this is the first record of *Dobellina* from a vertebrate host, and that *D. rayi* represents the second species of this new genus. The infection is 59%. Further observations on the cultivation of this amoeba and its effects upon the host in experimental conditions are in progress.

2. Observations on a new coccidium, *Eimeria himalyanum* n.sp., from the intestine of a Himalyan toad, *Bufo* sp.

H. N. Ray *and* P. L. Misra, Mukteswar.

This paper deals with the life-history of a coccidium, *E. himalyanum* n.sp. All the stages including the maturation of the oöcysts occur in the epithelial lining of the intestine of the host. Due to this intracellular habit of the parasite the oöcyst wall is very poorly developed and appears as a thin hyaline membrane. There are two kinds of schizonts: (1) macroschizonts releasing about 32 merozoites which develop into macrogametes, and (2) microschizonts, producing about the same number of merozoites which become males and give rise to about microgametes— a number which is quite unlike that of any Eimeriid hitherto described. The oöcyst is spherical in shape and measures 7μ to 10μ in diameter. There is no oöcystic residue. Sporocysts are spindle-shaped and measure 4·9μ in length and 2·8μ in breadth. Sporocystic residue is present. In stained preparations a siderophilous structure is seen at either pole of a fully formed sporozoite.

3. On a new coccidium, *Eimeria minetti* n.sp., from the lizard, *Mabuia* sp.

H. N. RAY, K. RAGHAVACHARI, *and* S. N. SAPRE, Mukteswar.

In this paper a detailed description is given of the life-cycle of a new species of *Eimeria* from the intestine of *Mabuia* sp. collected locally during the months of May to August. The parasite is confined to the small intestine and remains for the most part of its life attached to the epithelial lining of the gut wall. Oöcysts are oval in shape and measure 18μ to 21μ in length and 12μ to 14μ in breadth. There is no oöcystic residue. Sporocysts are spherical in shape and measure 7μ to 9μ in diameter. Sporocystic residue is prominent. Approximately nine species of *Eimeria* have been described so far from lizards and of these three, viz., *E. agamae* Laveran and Petit, 1910, *E. scinci* Phisaliz, 1923, and *E. flaviviridis* Setna and Bana, 1935, are known to infect the liver, bile-duct and gall bladder, while the rest (*E. raillieti* Leger, 1899, *E. gekkonis* Tanabe, 1928, *E. boveroi* and *E. rocha-limai* Carini and Pinto, 1926, *E. hemidactyli* Knowles and Das Gupta, 1935, and *E. knowlesi* Bhatia, 1936) are stated to be parasitic on the gut wall. Of these again *E. raillieti* is the only one of which certain endogenous stages have been known to occur in the epithelial lining of the large intestine. The coccidium dealt with in this article is the first of its kind to be described in detail.

4. Observations on a new coccidium, *Octosporella mabuiae* n.gen., n.sp., from the intestine of *Mabuia* sp.

H. N. RAY *and* K. RAGHAVACHARI, Mukteswar.

In this article the authors have described certain stages in the sporogony of a coccidium, the oöcysts of which are characteristically octosporocystid and dizoic. Schizogony of this parasite was not seen but structures, which appeared to be macrogametes or zygotes, were often found to be situated in the submucosa of the intestine. Oöcysts recovered from the faeces measured 14μ to 16μ in diameter. There was no oöcystic residue. The oöcysts, after being kept in 2·5% solution of Pot. bichromate, matured after 48 hours and showed eight spindle-shaped sporocysts measuring $8{\cdot}4\mu \times 4{\cdot}2\mu$. Each sporocyst showed two sickle-shaped sporozoites and a central residual mass. As the method of male gamete formation is not known as yet it is not possible to assign this new coccidium to any particular family under sporozoa.

5. Observations on a *Balantidium* from the intestine of *Hylobates hoolock*.

A. N. MITRA *and* M. M. CHAKRAVARTY, Calcutta.

A dead specimen of *Hylobates hoolock* was sent to our laboratory from the Zoological Gardens, Calcutta. A thorough examination of all the organs and tissues of the above specimen revealed that it harboured a species of *Balantidium* in its intestine. The infection was severe and this might have caused the death of the animal.

The shape of the parasite is ovoidal, both the anterior and posterior extremities being rounded and the size varies from 47·3–70·04μ in length and 37·08–59·84μ in breadth. The macronucleus is elongately oval in shape while the micronucleus is more or less spherical with an elongated chromatin rod at its centre. The presence of a boring apparatus and the axial and peripheral system of fibres around the mouth and peristome have also been described in detail.

6. The action of quinine sulphate on fresh-water Hydra.

HIMANGSHU LAL SARKAR, Gauhati (Assam).

From the chemically pure quinine sulphate powder with the help of distilled water a stock solution of 1 in 500 was prepared. From this stock solution different grade of dilutated solutions were prepared for conducting the experiments. The culture of Hydra from the glass aquarium were introduced in batches to all the grade of solutions. The average death time of each batch as well as all the batches taken together in a particular grade of solution were recorded.

Also the movements and behaviour of all the Hydra in the solutions are discussed in a generalized way.

7. On a new trematode *Diplozoon indicum* n.sp. from the gills of a fresh-water fish from Lucknow.

J. DAYAL, Lucknow.

Our knowledge of *Diplozoon* is based on two species only, (1) *D. paradoxum* Nordmann, 1832, from Europe, and (2) *D nipponicum* Goto, 1891, from Japan. No form has so far been recorded from India. The author has collected, for the first time in India, a large number of both immature and mature forms from the gills of a local fresh-water fish. The form has been allocated to a new species *D. indicum.* It differs from the two known species mainly in the following characters:—

1. In the smaller length of the posterior region of the body.
2. In the absence of median chitinous hooks in the hinder region of the body.
3. In the structure and extent of the intestine in the posterior region of the body.
4. In the position and shape of the genital organs, chiefly the testes.
5. In the size of the eggs.

A detailed account of the anatomy of the new form and the differences from the other two forms are given in the paper.

8. On a new trematode *Eucreadium eutropiichthyius* n.gen., n.sp. from the intestine of a fresh-water fish *Eutropiichthys vacha.*

J. DAYAL, Lucknow.

The new form *Eucreadium eutropiichthyius* n.gen., n.sp. belongs to the family Allocreadiidae, and the important characters in which it differs from the related forms are the position and structure of the cirrus sac, the position of the genital pore and the possession of a pointed protuberance at the anopercular end of the eggs. A detailed account of the anatomy of the new form and a discussion on the classification of the family Allocreadiidae is given in the paper.

9. On a new trematode *Plesiodistomum callichrius* n.gen., n.sp. from the urinary bladder of a fresh-water fish *Callichrous pabda.*

J. DAYAL, Lucknow.

The new form *Plesiodistomum callichrius* n.gen., n.sp. belongs to the family Gorgoderidae and the subfamily Anaporrhutinae. It differs from the related forms chiefly in the configuration of the testes, in the structure of the vitelline glands, in the presence of a Laurer's canal and in the

absence of an oesophagus. A detailed account of the anatomy of the form is given in the paper.

10. On the occurrence of the bat fluke, *Prosthogonimus ovimagnosum* (Bhalerao, 1926), in a dog.

G. D. Bhalerao, Izatnagar.

In this short paper a record is made of the occurrence of *Prosthogonimus ovimagnosum* from the small intestine of a dog in Calcutta. This parasite normally infects bats in India and other oriental countries and was first recorded by the writer in 1926 from the bat, *Nyctinomus plicatus*, in Rangoon. A short history of its occurrence in India and other countries is given. This is evidently a case of facultative parasitism. A few similar instances of this kind of infection are quoted and observations are made on the anatomy of the flukes from the dog.

11. On the occurrence of *Prosthogonimus putschkowskii* Skrjabin, 1913, in India.

G. D. Bhalerao, Izatnagar, *and* P. W. Gideon, Dharwar.

The species of *Prosthogonimus* that have been so far recorded from India are *P. cuneatus* from *Acridotheres tristis*, *P. Sp.* from *Ibis megalocephala* and *P. indicus* from a domestic fowl. Referring to the recent critical analysis of the genus by Witenberg and Eckman (1939) it is found that the latter two species are referable to *P. putschkowskii* Skrjabin, 1913. *P. indicus* Srivastava, 1937, is therefore regarded as a synonym of *P. putschkowskii*. Observations are recorded on the specimens of this species from *Ibis megalocephala* and *Ardeola gravi* from Dharwar.

12. A new species of the genus *Avitellina* (Cestoda) from ovines in the Punjab.

Mohammad Amin, Lahore.

An account of a new species of *Avitellina*, parasitic in the small intestines of sheep—*Ovis aries*—from southern districts of the Punjab, is given in this paper. Among the existing members of the genus *Avitellina*, *A. centripunctata* is the nearest ally of this species. The latter, however, differs from the former in the number of testes, small size of the ovary, slightly alternating arrangement of the uteri, disposition of the paruterine organs and the form of the egg-pockets enclosed by them. This form also shows some resemblance to *A. sudanea* and *A. goughi* in the number of testes and form of the egg-pockets respectively. However, it differs from *A. sudanea* in the development of the paruterine organ being inside the uterus, and from *A. goughi* in the number of testes.

13. The nervous system of the Cestode *Tylocephalum dierama*.

M. K. Subramaniam, Madras.

The nervous system of *Tylocephalum dierama* is very simple in plan. The brain is not constituted by a system of ganglia but is plate-like and differs from animal to animal depending on the stage of contraction of the head and myzorhynchus. From the brain bundles of fibres proceed and get distributed at the anterior edge of the myzorhynchus. There are large and small ganglionic cells in the brain. Thirty-two to forty-two nerves, all of the same thickness, run through the length of the proglottid chain. A meshwork of nerve fibrils connecting the nerve cords is present at the very anterior end of the proglottid chain but further behind, the meshes have differentiated themselves into ring commissures. The

commissure at the posterior end of each proglottid is plate-like. The nervous system of *Ligula* and *Schistocephalus* was supposed uptil now to be the most primitive as the insignificant development of the sucker grooves in these animals indicate a poor adaptation to parasitism. These animals have two main lateral stems and a far larger number of longitudinal nerves than any other Cestode. In *Tylocephalum dierama* all the nerves are of the same size and therefore it is thought that its nervous system is more primitive than that of the two above-mentioned animals. As simplicity of arrangement of the nervous system does not indicate poor adaptation in *Tylocephalum*—as evidenced by the presence of suckers—it is likely that further exhaustive studies may alter entirely the present conceptions regarding the phylogenetic relationships between the various orders of Cestoda.

14. On *Praegeria complexa* n.sp. from the sandy beach, Madras.

K. H. ALIKUNHI, Madras.

Subsequent to my paper 'On a new species of *Praegeria* occurring in Madras' read before the 27th Session of the Indian Science Congress, held at Madras, I have obtained a number of specimens of *Praegeria* which on careful study are found to belong to an undescribed species. The present species is much larger than the two other known species of the genus and measures about 10 to 25 mm. in length in the mature condition. The worms occur in coarse sand 2 to 3 inches below the surface between half and low tide levels. In external features, structure of the nephridium and its modifications and other internal characters the form shows relationship to *P. remota* and *P. gopalai*; but important differences are seen in the reproductive organs. In the male 4 to 6 groups of testes and a corresponding number of paired sperm-sacs and copulatory organs are developed. Each testis has a median position and is covered over by an extremely thin membrane. Copulatory organs are very complicated. Sperms are large, typical in structure but hardly motile. In the female up to 20 distinct paired ovarian groups have been observed, situated in alternate segments, the intervening segments being occupied by paired receptacula seminis. A covering membrane is present for the ovary also. Sperms in the receptaculum seminis differ in structure from those in the sperm-sacs of the male as they undergo modification after copulation. Reproductive organs both primary as well as accessory disintegrate and are lost after liberation of the mature sex elements. They are developed afresh when reproductive activities commence again.

15. On the occurrence of a fresh-water Oligochaete *Stylaria kempi* Stephenson in Lucknow.

S. M. DAS, Lucknow.

Stephenson, in his book 'Oligochaeta' (1930), mentions only two species of *Stylaria* from India: (1) *S. lacustris* and (2) *S. kempi*, the latter being reported from one locality (Bhim Tal, Kumaon Hills, U.P.) only. The author has collected a number of specimens of *S. kempi* from a tank in Lucknow. These specimens, though larger in size than those described by Stephenson, are definitely *S. kempi* on account of the total absence of eyes. The chief differences from Stephenson's specimens are its greater length, nodulus of ventral setae mesial or distal, ventral setal bundle of 7 to 10 setae, and the dorsal setal bundle with two very long hair setae.

Despite the temptation to allocate a new species to the *Stylaria* collected from Lucknow, the author considers the above-mentioned differences as belonging to two races or subspecies only. Observations on the peristaltic and anal movements of *S. kempi* are recorded in the paper.

16. The nervous system of the earthworm *Lampito mauritti* (Kinb).

R. VASUDEVAN, Annamalainagar.

The nervous system of *Lampito mauritti* presents the following features:—

(1) The ganglion formed by the union of the circumpharyngeal connectives lies in the anterior region of segment IV, below the oesophagus and may therefore be appropriately termed the sub-oesophageal ganglion.

(2) The nerves supplying the Prostomium, segment I and segment II arise from the circumpharyngeal connectives in segment III; the nerves innervating segment III have their origin from the ventral nerve cord in segment IV.

(3) Segment IV is innervated by only two pairs of segmental nerve trunks, which form two incomplete dorsal nerve rings.

(4) Segment V, and the succeeding segments of the body, except the last are innervated by three pairs of segmental nerve trunks, which give rise to three big dorsal nerve rings. In addition, in each of the above-mentioned segments, there is also a single small ventral nerve ring, which is formed by nerves arising from the third pair of segmental nerve trunks.

(5) The last segment is innervated, just like the other segments, by three pairs of segmental nerve trunks, but the posterolateral branches of the nerve cord give rise to two extra pairs of nerve trunks thereby forming five incomplete nerve rings. The ventral nerve ring is absent in the last segment. Further work is in progress.

17. The rôle of the gut and the nephridia in regulating the water-content of the body-fluids in earthworms.

K. N. BAHL, Lucknow.

It is now well known that in earthworms of the genera *Pheretima*, *Lampito* (*Megascolex*), *Woodwardiella*, and *Tonoscolex*, the main part of the nephridial system discharges its fluid products into the gut. It has all along been tacitly assumed that the nephridia are purely excretory in function, and that excretory products are discharged into the gut. In this paper experiments are described to show that the primary function of the nephridia is probably to regulate the volume and osmotic pressure of the body-fluids in the earthworm, and that they share this function with the alimentary canal.

18. Leeches parasitic in the air-passages of mammals.

M. L. BHATIA, Lucknow.

Leeches parasitic in the air-passages of mammals belong to the genus *Limnatis* and they have been recorded from Ceylon by Blanchard (1894), from Palestine, Syria, and Persia by Masterman (1908), and from Afghanistan and Baluchistan by Annandale and Kaburaki in the years 1920 and 1921 respectively. In all cases they were secured from the nasal-passages and larynx of man, horse, and cattle.

No genuine Indian example of a *Limnatis*, parasitic in the air-passages of mammals, has so far been found, and it is mentioned that those recorded must have been introduced by being carried in the air-passages of men and domestic animals.

Recently the author has received three specimens: one from Calcutta, one from Burma, and one from Lahore, and all these belong to the genus *Limnatis*. Their occurrence in these places is a new record of their distribution.

Investigations on their morphology are in progress.

19. Physiology of digestion in blood-sucking leeches.

M. L. BHATIA, Lucknow.

A leech ingests, at a single meal, several times its own weight of blood. After a meal, leeches seek concealment in the dark and remain quiet for several months. The blood is slowly digested and the digestion of a full meal may take nine to twelve months.

It is well known that the salivary glands of a leech secrete a substance called *hirudin* which prevents coagulation of the blood sucked by the leech, and that this blood remains stored in the crop-reservoir. While it is true that the coagulation of blood is prevented by *hirudin*, it has not so far been recorded, so far as I am aware, that the blood within the crop is always in a haemolized condition, so that there is no chance of its coagulation at all. By a series of tests it has been found that the crop secretes an alkaline enzyme which has the property of haemolyzing blood. Certain patches of cells in the wall of the crop give a staining reaction different from those of the rest of the crop, and it is believed that it is these patches that secrete the alkaline haemolyzing substance.

20. On the bionomics and distribution of a leech *Herpobdelloidea lateroculata* Kaburaki (1921).

M. L. BHATIA, Lucknow.

This small leech as described by Dr. Annandale is remarkably planarian-like in appearance and in its movements. About a dozen specimens were collected from amongst water weeds in a small pond in Lucknow. A few living specimens kept under observation show that they are carnivorous even cannibalistic in their habits. They swallow insect larvae, planarians and smaller leeches. The long pharynx has three prominent ridges, each bearing anteriorly a pair of stylets or teeth in the form of spines. These stylets help in capturing the food prey. The occurrence of this form in Lucknow is a new record of its distribution.

21. Pulsation of heart in *Thalassema bombayensis.*

D. S. DESHPANDE, Bombay.

The heart is tubular and of simple type and surrounds the posterior end of the fore-gut division of the alimentary tube. It has a dorsal and ventral heart in a sense when each one takes the roll of pumping the blood to the direction determined by the peristalsis. There is a anastomosis between the two hearts which surrounds the crop posteriorly. The reversal of peristalsis is clearly seen as one observes the dissected specimen in normal saline or filtered sea water under the dissecting microscope. In ordinary conditions the normal peristalsis takes place alternately changing the direction of blood flow every few minutes. But this regularity may be broken at any moment by resorting to reversal of peristalsis. The following factors induce or change the direction of blood flow :—

(1) Ratio between the anal and oral respiratory currents.
(2) Specific gravity of the coelomic water.
(3) Any contact with foreign body or any change in surrounding medium.
(4) The voluntary and involuntary contractions in the complicated muscular zonations of muscular parietes.

Such peculiar type of blood circulation in *Thalassema bombayensis* reminds one of that exists in tunicates where Dr. Herdman locates two centres one situated in Dorsal system and the other in the Ventral system which by interchanging the contractibility bring about the reversal of peristalsis.

22. Excretory vesicles of *Thalassema bombayensis*.

D. S. DESHPANDE, Bombay.

Situated at the posterior end of the body is found one pair of large anal vesicles. They are also called the posterior Nephridia. They open laterally in the rectum with their separate ciliated apertures. These vesicles are held in position by fine muscular fibres which are attached at various points to the body wall but except those they seem to float freely in the loops of the alimentary canal in the body cavity. They are almost the same length as the body of the animal. All along the body wall of these anal vesicles there are ciliated funnels. Their distribution is quite irregular and represents Nephrostomes of typical Nephridia. As regards their function they are excretory and also they control the amount of water in coelomic fluid.

23. Locomotion of *Thalassema bombayensis*.

D. S. DESHPANDE, Bombay.

The locomotion in *Thalessema bombeyensis* is somewhat similar like that of the earth-worm. It elongates the anterior part of the body and then forces forward the viscera and the water-content in the coelomic space of the body by contracting the posterior region and relaxing the anterior region. When most of the coelomic fluid and viscera is forced forward to the anterior end the posterior end is drawn up. These movements are repeated as the animal moves forward. All these movements are possible provided there is the smooth substratum. Even in the burrows, i.e. in the residential quarters the mode of locomotion is the same but for the additional advantage of wedging the body by the anterior hooks to the side wall of the burrows. Its movement in the burrow is dashing and rapid and it can move backward nearly as fast as forward.

24. Copepoda from some mountain lakes in Kashmir.

G. L. ARORA, Lahore.

The present paper deals with an ecological and taxonomic study of the Copepoda collected from seven high mountain lakes in Kashmir, during the summer of 1940, when the author accompanied a party of Research workers from the Zoology Department of the Punjab University. The collection includes about nine species of Copepoda belonging to the sub-orders Calanoida and Cyclopoida.

25. On the embryology of Squilla.

K. BHASKARAN NAIR, Trivandrum.

The paper deals with the early embryonic development of two common Stomatopods, *Squilla raphidea* and *Squilla wood-masoni*, of the Madras coast. The growth of the egg inside the ovary has been traced. The earliest oocyte shows a central nucleus containing a promonen nucleolus. As the egg ripens the germinal vesicle breaks down. This happens much earlier than is usual among most of the Crustacea. When extruded the eggs are found to be undergoing the first polar division. The maturation spindle is extremely small and is situated at the periphery of the egg. The mode of cleavage is the same as in the Peracarida and the Leptostraca and differs from that of the Dacapoda. The blastomeres rise to the surface individually and form a uniform layer of cells all round. There is no superficial differentiation of the germ layers. Gastrulation takes place by immigration of cells from a blastoporal depression. The cells

that wander inwards are mesendodermal in nature. They give rise to yolk cells, which arrange themselves along the periphery of the yolk mass below the germinal band; and mesoderm cells which form the naupliar somites. The preantennulary mesoderm arises separately at the anterior end. The post-naupliar ectoderm and mesoderm are teloblastic in origin and the arrangement of the teloblasts is similar to what is found in *Nebalia*. The midgut rudiment is formed by cells which slip in last from the blastopore. These cells are all endodermal. The rudiment grows by the addition of modified yolk cells. The liver is formed by the folding of the sides of the epithelial endodermal plate. The formation and growth of the preantennulary and trunk mesoderm are described. Segmental coelomic spaces are formed in the post-naupliar region of the body. No dorsal organ is developed. The latest stage obtained shows four pairs of appendages in the abdomen and a faint pigmentation in the optic rudiments. The paper discusses these results in the light of modern work on Crustacean embryology and closes with a consideration of their significance in tracing the affinities of the Stomatopoda.

26. Nest balls of coprinae with a description of three balls of *Heliocopris* (Coleoptera).

S. M. DAS, Lucknow.

It is well known that Coprinae (Coleoptera) roll balls of dung and prepare to lay eggs in them after they have been carried into the burrows. These nests are found from 2 to 8 feet below the surface of the ground. In some species, each cell (nest) is enclosed in a thick layer of outer clay, which becomes so hard that those first discovered were supposed to be ancient stone cannon-balls. The size, shape and structure of these balls have been studied in several species, but not many Indian species have been worked out.

The author collected, in January 1939, four such balls in Lucknow. One was opened and was found to contain a live grab of a Coprinae, while the other three were left to develop and were finally opened in November 1939. All the three contained an adult *Heliocopris* each, two belonging to the same species *H. dominus* and the third being *H. gigas*. A detailed description of the size, shape and structure of these nest balls, and the differences between the balls of the two species is given in the paper.

27. Cytoplasmic inclusions in the oogenesis of cattle-tick *Hyalomma aegyptium*.

GOPAL SINGH DEOL, Lahore.

Work on the oogenesis of this tick was undertaken as, to the best of my knowledge, the eggs of the ticks had not been investigated by any modern worker. In the course of my investigation Dr. R. Dass published a paper on the eggs of dog-tick, *Rhipicephalus sanguineus* (latreille) (*Zeit. Zellforsch*, 1939).

Certain important differences have been brought out in the oogeneses of these two ticks. In *H. aegyptium* there is no albuminous yolk whereas in *R. sanguineus* (latreille) there are prominent yolk discs of albuminous nature.

Both the mitochondria and golgi bodies are juxtanuclear to begin with and they gradually spread out in the cytoplasm.

In *R. sanguineus* (latreille) no fat has been described but in *H. aegyptium* there are fat bodies as revealed by Sudan IV (Kay and Whitehead), which stains even the weak fat. It may be noted that Dr. R. Dass was unable to use this technique on his material.

28. A new water spider from Dal Lake, Kashmir.

SUKH DYAL, Lahore.

This spider, *Amphinects* sp. novo, was collected from Dal Lake in September, 1936. It belongs to the family Agelenidae which has a number of other water spiders, such as *Desis*, *Cambridgea* and *Argyroneta* sp. The spider is a good diver, and swims under water by powerful backward rhythmic strokes of its legs. Now and then the spider comes to the surface to renew its air supply. When it dives the entire surface of the body gets covered by an air bubble which gives it a silvery brightness.

29. A preliminary note on the development of *Ariophanta bistrialis* Beck.

T. S. BALASUBRAMANYAM, Annamalainagar.

The eggs of *Ariophanta bistrialis* take ten days to hatch. The present note records the main events of development on each day. The first rudiments of the nervous system appear on the third day, and the definitive form is attained on the sixth day. The larval heart and larval kidney (which is C-shaped) make their appearance on the third day. The differentiation of the mesoderm into the rudiments of the heart, pericardium, and kidney commences on the fifth day, and by the end of the sixth day the definitive heart begins to pulsate. The podocyst, a very characteristic organ of the Stylommatophorous embryos, appears on the fifth day and attains its maximum growth on the seventh day. The special embryonic organs, the larval kidney, the head-vesicle, and the podocyst disappear about the time of hatching.

30. On some ascidians from Madras.

S. M. DAS, Lucknow.

The ascidian fauna of the Indian seas has not yet been systematically worked out. Herdman (1906) wrote a report on the ascidians from the gulf of Manaar and Ceylon, while Oka (1915) published a paper on ascidians in the collection of the Indian Museum; but the specimens in the latter collection were from random samples, and it does not give a true representation of the fauna of the Indian coasts. The present paper contains a report on a collection of monascidians from Madras. Six species are described, one of which is new to science.

The new species described is *Herdmania ennurensis* Das (*Proc. Ind. Acad. Sci.*, Vol. 11, No. 1). The other five species are: *Ascidiella aspersa* O.F.M., *Styela areolata* Heller, *Microcosmus manaanarensis* Herdman, *Polycarpa annandelei* Oka, and *Herdmania pallida* Lahille. There is no record of *Ascidiella* either in Herdman's report (1906) or in Oka's (1915) description of Indian ascidians. This is, therefore, the first record of *Ascidiella* from India.

31. On a collection of fishes from the Dal Lake, Kashmir.

NAZIR AHMAD, Lahore.

The present paper deals with eleven species distributed amongst five genera and two families. The family Cobitidae is represented by *Botia birdi*, *Nemachilus vittatus*, *Nemachilus kashmirensis* and *Nemachilus marmoratus* and the family Cyprinidae by *Labeo dero*, *Crossochilus punjabensis*, *Schizothorax esocinus*, *Schizothorax niger*, *Schizothorax planiforns*, *Schizothorax labiatus* and *Schizothorax hugelii*. Sexual dimorphism is being recorded for the first time in Schizothoracinae.

32. On the smallest (?) Elasmobranch egg.

N. V. Choodamani, Madras.

Scoliodon sorrakowah Garman, is a viviparous Elasmobranch common in the Madras coast. An excellent account of the placenta in this form has already been given by Miss G. Mahadevan. The yolk-sac, even when the embryo is 20 mm. long, gets into relation with the cup-like trophonemata, and establishes a connection with it. But the very early stages before attachment were not available to her and could not be worked out. The present paper gives a preliminary account of the early developmental stages.

The mature eggs of this form measure only one millimetre in diameter, a remarkable feature among Elasmobranchs which have large eggs with much yolk. A few batches of intra-uterine eggs were obtained. Each egg is enclosed in a transparent pear-shaped bag, the narrower end of which is slightly drawn out and twisted.

It was expected that there would be some peculiarity in the early development of this form due to the small size of the egg and the reduced quantity of yolk, and this surmise has turned to be correct. In the earliest stage examined the blastoderm cells have grown over one-third of the egg. In the next stage the blastoderm is found to have grown over the yolk leaving a circular area through which a mass of yolk, the yolk-plug, projects. Now the edges of this blastoporal rim are observed to have turned inwards enclosing the greater portion of the yolk, a process which reminds one of what takes place in Polypterus, in the Dipnoi and in the Frog. In another stage examined the ingrowth has continued until the incurving edges have met and almost completely enclose the internal yolk. Due to want of material further details of this interesting process of gastrulation cannot yet be given.

There is a quick differentiation of the embryo, the yolk-cord and the yolk-sac. A short account of the embryos in very early stages of development is also given.

33. The spermatogenesis of *Chiloscyllium griseum* (Müller and Henle).

(Miss) C. K. Rathnavathy, Madras.

The young testis consists of a compact group of cells in which may be distinguished spherically and polymorphically nucleated cells both of which may directly or indirectly give rise to spermatogonia. This group of cells is enveloped by the germinal epithelium which gives origin to the two types of cells mentioned above.

Within the nucleus of the primary spermatogonium is present a large plasmosome. The centrosome is situated close to the nuclear wall while the mitochondria in the form of granules and rods, and golgi in the form of rings and crescents lie in close association with the centrosome. At this stage the formation of cysts is observed within the testis. During the spermatogonial telophase the golgi and mitochondria are distributed almost equally to the two daughter cells. The secondary spermatogonia are thus constituted which as a result of division give rise to the primary spermatocytes. The mitotic changes pass through the primary spermatocyte and as the cell reaches the metaphase stage it exhibits thirteen chromosomes on its spindle which is the reduced number of chromosomes. With the completion of the telophase stage the golgi and mitochondrial elements are approximately distributed to the daughter cells. The secondary spermatocyte stage is quickly passed through and the spermatid is constituted, with the transformation of which a very peculiar and interesting phenomenon associated with the abrupt formation of the axial filament is encountered. The golgi bodies fuse to form an acroblast

which secretes the acrosome, the mitochondria form an enveloping sheath to the axial filament while the nucleus constitutes the head. The maturing sperms which are very much elongated and arranged within the cysts in bundles get attached to sertoli cells by their head ends and when they are fully mature lose this connection and finally get expelled from the cysts.

34. Some observations on the development of *Arius jella*.

K. CHIDAMBARAM, Madras.

It is well known that *Arius jella* lays huge eggs with an immense quantity of yolk. For the first time the development of this form is being worked out. The male carries the eggs deep in its pharynx and thus exhibits the interesting phenomenon of oral gestation. The breeding of the fish extends from about the first week of August to middle of January. About 30 to 40 eggs are laid each time. The incubation period is long and lasts for nearly two months, the embryos remaining inside the mouth of the male till the yolk is completely absorbed. Various stages of developing embryos have been collected and observed. It has been found that in the first 20 days of development growth is gradual. During the next 10 days it is much more rapid and the young hatches out about the 30th day after commencement of incubation. The embryos which are very active continue to live for a month more inside the oral chamber before they come outside to start independent existence. Details in regard to the various stages of development are given in the paper.

35. On two kinds of fish eggs hatched out in the laboratory of West Hill Biological Station, Department of Fisheries, Calicut.

D. W. DEVANESEN *and* K. CHIDAMBARAM, Madras.

Two types of fish eggs, viz., those of *Anodontostoma chacunda* and those of *Caranx crumenopthalmus*, found in the plankton collected opposite the Marine Biological Station, Calicut, in January, 1940, were hatched out on several occasions in the laboratory and their development observed.

The eggs of *Anodontostoma chacunda* are yellow with a number of colourless oil-globules distributed in the yolk. The diameter of the entire egg is about 0·82 mm. Just before hatching, the oil-globules about twenty in number collect together at the region corresponding to the middle of the future larva and the posterior portion of its yolk sac. The larvae generally hatch out at about 1 P.M. Their average length is 2·66 mm. A reduction in the length of the trunk is noticed during the growth of the larvae.

The eggs of *Caranz crumenopthalmus* are characterized by vacuolated yolk and the presence of a single oil-globule with brownish red pigment spots. The diameter of the egg is about 0·78 mm. and that of the oil-globule 0·24 mm. The larvae hatch out by about 1·30 P.M. Their length is about 1·35 mm. The oil-globule occupies the anterior portion of the yolk sac. An increase in the length of the trunk is noticed during the growth of the larvae.

36. On the morphology and histology of the gas-bladder in *Boleophthalmus boddarti* (Pallas).

M. RAHIMULLAH, Hyderabad-Deccan.

The author has briefly described the external features and histology of the gas-bladder in this fish. It is a small ovoid or ellipsoidal structure, and of a physoclistous type, lying freely in the abdominal cavity, on the

dorsal side, above the viscera, and is supported by the mesentery. It possesses a star-shaped gas-gland with 5 retia mirabilia.

The histology of the gas-gland has been thoroughly dealt with.

37. On the disposition of the so-called pyloric caeca in a Brotulid fish, *Sirembo imberbis* (Tem. & Sch.).

M. Rahimullah, Hyderabad-Deccan.

In this paper the author has described the disposition of the so-called pyloric caeca in a Brotulid fish, *Sirembo imberbis*, obtained from Ennur, which number 15 in all. They are bilaterally arranged in linear rows—9 caeca on the left side, and 6 on the right side.

Other references and details have also been given.

38. On the development of mesonephros in a Teleostean fish, *Thynnichthys sandkhol* (Sykes).

M. A. Moghe, Nagpur.

The development of mesonephros in Teleosts has been described by various investigators. Rosenberg (1867), Goette (1875), Fürbringer (1878), and Hoffmann (1886) ventured the suggestions that mesonephric tubules are formed from solid condensations of cells or from cell masses lying in close proximity to the Wolffian ducts. The origin of the cells forming these condensations or masses has been variously described: (*a*) from the ventral wall of the aorta or/and the parietal cells of the wall of the cardinal vein (Rosenberg, 1867); from cells of the parietal epithelium (Goette, 1875 and Fürbringer, 1878); (*c*) from solid peritonial invaginations (Hoffmann, 1886); (*d*) from by proliferation from the cells of the Wolffian duct (Nussbaum, 1878 and Felix, 1897).

The accounts given in textbooks (Kerr, 1919, Brachet, 1935) are based exclusively on the work of Felix. He derives the mesonephric tubules, in the first instance, from solid aggregates of cells formed by proliferation from the wall of the archinephric duct. According to him, these tubules are *replaced* by the tubules of permanent mesonephros formed from cells of unknown origin. If this account of the formation of mesonephric tubules is true, it is evident that Teleostean fishes is the only group among vertebrates in which such an origin of the mesonephros takes place. Further, it should be possible to trace the cells forming the permanent mesonephros to some embryonic source. Recently Maschkowzeff (1934) has traced the origin of nephrogenetic mesenchyme to the 'intermediate cell mass'. His work is very incomplete and it is not clear whether he accepts Felix's view of the existence of a temporary and a permanent mesonephros.

A detailed account of the development of mesonephros is given in this paper and the conclusion is drawn that the tubules develop from condensations of cells arising from the intermediate cell mass. The teleostei fall, therefore, in general line with all the other anamniota.

39. Proteid yolk formation in fishes.

Ram Saran Das, Allahabad.

Parat (1927), Hibbard and Parat (1927), Nath and Nangia (1931) have shown that proteid yolk in the fishes investigated, develops by the gradual condensation of the contents of neutral red vacuoles. On the other hand, according to Narain (1930) the albuminous yolk bodies are formed by the direct transformation of mitochondria. In order to shed further light on this problem the ovaries of a number of locally available fishes have been examined with the help of the modern cytological techniques. It has been found that the account of the development of proteid

yolk as given by Parat and Nath is substantially correct. Proteid yolk bodies do develop in vacuoles that take in stain with neutral red. Nevertheless, it has been ascertained during the course of his piece of work that only a limited portion of the total proteid yolk contents of the mature egg is produced in this way. The process definitely comes to an end at a fairly early stage of egg growth after which the proteid yolk bodies are formed by the swelling and gradual transformation of mitochondria. The latter process provides the greater bulk of albuminous yolk of the mature

40. Some further observations on the respiratory movements of an air-breathing loach, *Lepidocephalus guntea* (Hamilton Buchanan).

B. K. DAS, Hyderabad-Deccan.

In this paper the author proposes to discuss particularly on the following points:

(*a*) Behaviour and respiratory activities of the fish in moist conditions.
(*b*) Effects of natural dirty water on the respiration of the fish.
(*c*) Effects of clear water obtained from its natural habitat on the respiration of the fish.

41. A preliminary note on the morphology and histology of the alimentary tract of an air-breathing fish, *Anabas testudineus* (Bl).

SYED MOHD. MOHSIN, Hyderabad-Deccan.

(*A*) *General account.*

The stomach is sac-like and is connected with the pharynx by means of a small tubular oesophagus. Intestine is slightly coiled and looped. Three so-called pyloric caeca of about equal size are present.

(*B*) *Histology of the alimentary tract.*

The histology of the alimentary tract presents the following salient features:—

(i) *Oesophagus* shows a transition in the nature of its epithelium from the anterior to its posterior region, where it gradually resembles that of the cardiac end of the stomach.
(ii) *Stomach* shows very prominent folds of the galndular epithelium in the cardiac region, and the glands are very striking.
(iii) *Pylorus* presents a kind of sphincter muscle formed by the great development and thickening of the circular layer of muscle fibres, more or less in the form of a valve.
(iv) *Intestine* has the typical structure—goblet cells being very numerous.
(v) In the *rectum* there is a kind of valve, situated at the junction of the small intestine and the rectum.
(vi) Histology of the so-called pyloric caeca is also being dealt with.

42. The interstitial cells in the testis of *Ichthyophis glutinosus* (Linn.).

B. R. SESHACHAR, Bangalore.

The interstitial tissue of the testis of *Ichthyophis glutinosus* varies in quantity and distribution in the active and resting conditions of the

testis. In the former condition, it occurs as scattered groups of cells in the interstices of the locule while in the latter, it is seen in the form of large number of nests of cells between the locules. The development of the interstitial tissue is found to be inversely proportional to the development of the sexual cells of the testis. Fat is a characteristic cytoplasmic content of the interstitial cells and is believed to have arisen by the activity of the golgi bodies. The significance of the interstitial tissue in *Ichthyophis* is unknown.

43. Oesophageal arteries in frogs and toads.

J. L. BHADURI, Calcutta.

The origin of oesophageal arteries from the systemic arches of frogs and toads shows a good deal of variation. This was first hinted at by the author in a previous paper and recorded by Hoffmann in different species of frogs and toads. The author has reinvestigated this question. In frogs (*Rana*) the oesophageal artery originates either independently or sometimes from the basal part of the occipito-vertebral artery (Gaupp, Crawshay, Bhaduri, Hoffmann) and in toads (*Bufo*) there is a single left-handed origin of the oesophageal artery quite in a different level (Bhaduri, Hoffmann and Al-Husani). But there is a branch ('pharyngeal factor') from the occipito-vertebral artery which supplies the pharynx in *Bufo*. This 'pharyngeal factor' has been observed by Hoffmann in different species of frogs and toads (*Bufo*, *Phyxicephalus*, *Heleophryne* and *Chiromantis*). Al-Husani also substantiates the author's observation in Egyptian toads (*Bufo*). The author, however, finds difficulty in homologizing the single (left-handed or right-handed) oesophageal artery, as is found in *Bufo*, *Rana* and *Heleophryne*, with the oesophageal arteries of frogs as recorded by previous authors (Gaupp and others). In the light of recent studies and having due regard to comparative anatomy, the author is of the opinion that the 'pharyngeal factor' of the occipito-vertebral artery recorded in *Bufo, Heleophryne, Phyxicephalus* and others can easily be homologized with the oesophageal arteries of frogs (*Rana*) and be called the primary or true oesophageal artery even though it does not supply the oesophagus. In view of this, the single (left-handed or right-handed) origin of the oesophageal artery should be viewed as a secondary acquirement and called secondary oesophageal artery.

44. Some aspects of the head of *Xenopus laevis*.

L. S. RAMASWAMI, Mysore.

The cranial morphology of the adult head of *Xenopus* was described by de Villiers and recently Paterson has given a complete account of the chondrocranium prior to metamorphosis and of the adult head. Unfortunately this author has not studied the metamorphosis and through the courtesy of Paterson, I acquired some metamorphosing stages.

In the auditory region of the metamorphosing tadpole, a cartilaginous attachment of the pars media plectri with the otic capsule anterior to the foramen ovale is noted. The separate foramina for the optic and oculomotor nerves from the early stages as described by Paterson is confirmed; but the remark of Paterson that the pila metoptica occurs only in the last stage of *Xenopus* is questioned. A palatine branch of arteria carotis interna is described. The nomenclature of the cartilage spanning the pars articular region of the quadrate and the anterolateral tip of the ethmoid plate as 'quadratoethmoidal' cartilage is criticised; the name 'pars articulo-trabecular' commissure is suggested since the term quadra-

toethmoidal cartilage is preoccupied. The formation of the adult subocular bar is described.

45. On the structure of the conus and the mode of distribution of blood along the various arches of the Anura.

B. THIRUMALACHAR, Tumkur.

A certain amount of difference of opinion has been noticed regarding the structure of the conus and the mode of distribution of blood along the various aortic arches in the Anura. This led us to undertake a fresh study of the subject.

A representative collection of all the families of Anura has been taken up for study. Wax models were made to aid us in making out in detail the structures inside the conus.

In almost all the specimens, excepting such primitive forms like *Pipa*, *Alytes*, *Xenopus*, etc., the spiral valve is a very well-developed structure capable of separating the conus into two distinct chambers—the Cav. Aorticum and the Cav. Pulmocutaneum. In these primitive forms there is at the cranial end of the conus a common ventral Systemicocarotidium. This is due to the septum medianum not running up to the anterior end of the spiral valve. In all the other forms the ventral division of the truncus is separated into right and left portions by the septum medianum establishing close contact with the anterior end of the spiral valve.

In the arrangement of the different arches, which spring from the conus arteriosus, there is a transition from the conditions as seen in Urodeles to conditions as seen in reptiles. In primitive forms the two carotids arise from the systemic arches of the corresponding sides, rather far apart. A tendency is noticed for these to approximate towards each other, near to the point of forking of the systemics. In some others the left carotid shifts its place of origin from the left systemic arch to the right systemic, as in reptiles.

Regarding the mode of distribution of blood along the various arches, there is no difference of opinion regarding the pulmonary blood, it enters the pulmonary arch. It is only regarding the course of the rest of the blood stream that there has been some confusion. In primitive forms like *Pipa* and *Alytes* there is a free admixture of bloods in the ventral chamber of the truncus. In all the others the mixed blood passes only into the left systemic arch while part of it along with the entire part of the pure blood enters the right systemicocarotidium. The carotid glands may be of some use in directing only the last few drops of richly oxygenated blood into the carotid arches.

46. A note on a peculiar association of the corpora adiposa in a common Indian bull frog, *Rana tigrina* (Daud.).

MOHD. A. R. KHAN, Hyderabad-Deccan.

In Amphibia corpora adiposa or fat-bodies are normally associated with the gonads and the kidneys and are derived from the anterior portions of the genital ridges, but, curiously enough, in an adult ♀ frog under investigation, these bodies, in addition to their normal position, were found to be attached with the *left* lung also—this lung being very large as compared with its right counterpart and its dorsal wall was fused with the dorsal abdominal muscles.

All details of measurements have been given, and the histology of the corpora adiposa associated with the left lung has been fully discussed and compared with the normal structures.

47. Corpus luteum in the sea snake *Hydrophis cyanocinctus*, Daudin.

(MISS) M. SAMUEL *and* R. GOPALA AIYAR, Madras.

Hydrophis cyanocinctus a common sea snake of the Madras coast is viviparous and we find from Mr. L. R. Kasturirangan's investigation in this laboratory that it has a highly specialized allantoplacenta. Nine gravid females were obtained during March-April, 1940 and the ovaries were removed and several ruptured follicles in different stages of development of the corpus luteum were studied.

As in mammals three layers are concerned in the formation of the corpus luteum:—(1) follicular epithelium, (2) theca interna, (3) theca externa. The histological changes taking place inside the ruptured follicle after the escape of the egg till it has become a glandular organ have been described. Six stages in the development of the corpus luteum are studied from the earliest to the latest when degeneration of luteal cells commence. It is found that the luteal tissue is formed by the hypertrophy of the follicular epithelium and there is an invasion of connective tissue and cells of theca interna carrying blood capillaries into the luteal tissue. Mitotic division of the luteal cells has not been observed.

48. A preliminary account of placentation in *Enhydrina schistosa* (Daudin).

L. R. KASTURIRANGAN *and* R. GOPALA AIYAR, Madras.

The discovery of an allantoic placenta in a reptile in 1891 forms a landmark in the history of Vertebrate Embryology. Since Giacomini's day little work has been done on Reptilian Placentation. It was thought that the viviparous sea-snakes might possess a placenta; so a study of the Indian forms was commenced.

In *Enhydrina schistosa*, it is found that (1) the shell-membrane disappears almost completely, (2) the chorion and the uterine epithelium are intimately united, (3) there is an allantoic placenta. Hence this species should be recognized as truly viviparous.

The placenta is formed by the modification of the uterine epithelium on the one hand and the allantochorion on the other. It includes two distinct regions. One region is characterized by the very superficial position of the maternal capillaries and the allantoic capillaries. The proximity of the two blood streams, doubtless, serves for respiratory exchange. In the other region the uterine epithelium is glandular while the chorion is enormously thickened and its deeper portion is highly vacuolated assuming a sponge-like consistency. The function of this region seems to be the facilitation of the transfer of fluid material, probably of a nutritive nature, from the maternal to the foetal tissues. The placental condition in *Enhydrina* is compared with the conditions described in other reptiles and the differences are pointed out.

49. Olfaction in snakes.

D. S. DESHPANDE, Bombay.

Snakes breathe by rib movements. The food is swallowed whole and therefore the necessity for keeping the mouth open for a long time is not essential. Hence there is never a longer period during which the acuity of olfactory sense is interpurated. Now if the mouth is to remain open and at the same time the power of olfaction is to be maintained, there should be further modification of the necessary apparatus. In the snakes the larynx is mobile and can be moved by muscles arising from the lower jaw, the hyoid, and the muscles of the pharyngeal floor, and also by the movement of these muscles it can be brought into firm apposition with

the hinder end of the nasal tube. The mouth is opened now and then to allow the protrusion of the tongue and there is no respiratory reason as to the entrance of the air through it. Only for a while the olfaction would be interfered with and to remedy this the mechanism of apposition is evolved. When the large rat is swallowed there is protrusion of the larynx, while the bolus slowly passes through the mouth so as to provent suffocation. During this time the olfactory sense is of necessity in abeyance for the reason having once secured the food, however, it does not need to smell for more.

50. Feeding habits of cobras and pythons.

D. S. DESHPANDE, Bombay.

Like other reptiles these creatures often swallow objects of enormous size as compared with their own bulk. The process is very slow one and lasts from an hour to six hours and at times something like twelve hours in the case of pythons swallowing a rabit or a hen. It starts with killing of the prey by encircling of it by several coils of the body and squashing of it into the shape of a sausage. The bolus is then lubricated with salvia and is taken into the mouth. The teeth of the snake are set back and hold the animal and the gut then creep over it. As the feeding process may take a long time, the passage of air to the larynx might be obstructed. To overcome these difficulties the larynx is of remarkably mobile type and has protractor and retractor muscles of its own. By the former it can be protruded right up to the level of the front teeth and is then enable to open and allow inlet of air. There is no rule as to starting of feed by head or tail of the prey as has been observed in the laboratory by myself. At times the larger and at times the smaller prey was given to the cobras and pythons which were collected locally. On all occasions both the varieties started taking their meals at the point which comes to the region of mouth first. Some started their feast at the head end of the prey, others at the tail end and some even at the mid-region of the prey.

51. Report on the occurrence of 'Phoorsa' (the saw-scaled viper—*Echis carinata*, Schn.) in the Hyderabad State.

SYED MEHDI ALI, Hyderabad-Deccan.

While examining a collection of the Ophidian fauna of the Hyderabad State the author discovered three specimens of 'Phoorsa' (the Saw-scaled viper—*Echis carinata*, Schn.). This viper is of rare occurrence as compared with the Russell's viper or the 'Daboia' (*Vipera russelli*, Shaw) which is so commonly distributed all over the State.

The author has given all details of its measurements and has fully discussed the distribution of this viper. He has also compared it with a very interesting mimic, viz., the 'Gamma' snake [*Dipsadomorphus* (Syn. *Dipsas*) *trigonatus*, Schn.—an Opisthoglyphous colubrid] which is fairly common in the State.

52. Gross changes in the testes of *Passer domesticus*.

A. B. MISRA, Benares.

The sexual cycle of *Passer domesticus* may be classified under two heads, the one progressive and the other regressive phase. The bird has two sexual cycles during the year. The climax of the progressive phase is reached once in April, and, again, in September. In the April cycle, the volume attained by the testes is greater than that in the September cycle. The regressive phase extends from October to the first week of January,

and the progressive phase from May to July. The minimum size of the testes in July is greater than that in January.

During the regressive cycle, the tunica albuginea becomes excessively nucleated and a large number of cells from this zone migrate into the intertubular spaces so that the seminiferous tubules are surrounded, on all sides, by them. Some of these interstitial cells enter the seminiferous tubules through the tunica propria and thus come to lie inside the tubules. By a process of cytomorphosis, these cells become metamorphosed into germ cells. The tubules are then activated into spermatogenesis leading to the production of spermatozoa required for the breeding season. As the breeding season advances, the seminiferous tubules are emptied of their contents and a cavity appears in most of the tubules. This is also accompanied by a process of desquammation of cells within the tubules so that effete cells are got rid of. The seminiferous tubules then contract in diameter and the second cycle sets in. Pigment is absent in the testes of *Passer domesticus.*

53. The reproductive cycle of the Indian Mynah, *Acridotheris tristis.*

S. N. MEHROTRA, Benares.

The annual sexual cycle in Mynah, *Acridotheris tristis*, consists of a progressive and a regressive wave. The former extends from January to June when the testes gradually enlarge in size and spermatogenic activity reaches its zenith in May and June; and the latter lasts from July to December.

The tunica albuginea is fibrous during the period of dormancy of the testes but becomes richly nucleated before the onset of the progressive phase.

The interstitial tissue cells appear in large number in February, and surround the tubules, even forcing their way into their interior through their damaged coverings (tunicae propriae).

On reaching the interior of the tubules, these extraneous cells multiply amitotically at first to augment their numbers and then metamorphose into spermatogenic cells.

A kind of selective elimination of the weak or effete cells takes place inside the seminiferous tubules soon after the reinforcement of their cellular contents with interstitial cells from the outside.

The seminiferous tubules enlarge in size during the progressive cycle of the testes, and in April, May and June spermatogenesis actively takes place in them resulting in the production of a large number of spermatozoa. At this stage, the interstitial cells are in their minimum strength.

At the close of the breeding season, regressive changes take place in the tubules, which shrink in size and the reproductive cells pass into a dormant condition. The interstitial cells, at this stage, reappear in numbers and occupy the intertubular spaces within the testes. Prior to the onset of the breeding season, some of the interstitial cells change into glandular cells.

In *Acridotheris tristis*, pigment is not so conspicuously present in the testes as in some other species of birds. Very small quantities of it occur in the testes of this bird in the month of February.

54. A study of the spermatogenesis in Mynah, *Acridotheris tristis.*

S. N. MEHROTRA, Benares.

During active spermatogenesis in *Acridotheris tristis*, all the four types of cells, viz., spermatogonia, primary spermatocytes, secondary spermatocytes, and spermatids, can be made out. The cells of sertoli can be made out only during the period of active spermatogenesis. These cells decay

after nourishing a number of spermatids and spermatozoa. It is just a matter of chance that a spermatogenic cell becomes converted into the nourishing cell (cell of sertoli) instead of transforming itself into a germ cell.

The spermatid metamorphoses into the spermatozoon. The centriole divides into two which remain connected together by means of a fibril. The proximal centriole moves towards the nucleus and adheres to it, while the distal centriole assumes the form of a ring, through which the fibril projects out and eventually gives rise to the axial filament and the axis of the tail. The fibril connecting the two centrioles becomes plastered with mitochondria, thereby giving rise to the middle piece. The proximal centriole produces the neck region. Golgi elements together with the idioplasm are concerned in giving rise to the acrosome in *A. tristis*. The acrosome in this case lengthens out considerably and becomes thallus-like in form.

Unripe spermatozoa do not possess a twist on any part of their body, but, as they ripen, the sperm head and the middle piece become twisted more and more.

55. Some observations on the muscles of the fore-limb in the Indian Langur, *Semnopithecus entellus*.

A. ANANTHANARAYANA AYER, Vizagapatam.

The origin of m. trapezius extends from occiput to tenth dorsal spine. It lacks clavicular insertion. Origin of m. latissimus dorsi extends from eighth dorsal spine downwards along thoracic and lumbar spines, from lumbar aponeurosis and from 11th and 12th ribs. At insertion a dorsal part partly unites with m. teres major. M. rhomboid forms a continuous sheet from superior nuchal line to upper thoracic spines. M. atlanto-scapularis anterior extends from axis and atlas to lateral part of scapular spine. M. atlanto-scapularis posterior from atlas to medial angle of scapula might be regarded as uppermost slip of m. serratus anterior; this takes origin from all cervical transverse processes and from upper eight ribs. M. pectoralis major lacks clavicular origin. Mm. pectoralis abdominis, pectoralis intermedius, pectoralis minor and panniculus carnosus are attached to a deep pectoral aponeurosis. Deltoid origin extends on to the whole length of clavicle. Coracobrachialis is in two separate parts. Biceps insertion has no lacertus fibrosis. M. brachialis shows imperfect splitting into two parts. Dorsoepitrochlearis is present. M. pronator teres lacks deep head. Deep aspect of sublimis sends a slip to profundus. M. flexor pollicis longus is not isolated from profundus, though profundus shows partial splitting into two or three parts and supplies all digits. Extensor minimi supplies 4 and 5 digits. M. epitrochleo-anconeus is present. M. extensor pollicis brevis is absent. The contrahentes gives tendinous slips along 3rd and 4th metacarpals and muscular slips to 4th and 5th digits and the adductor pollicis may be considered to be a part of it.

56. On the development of the vertebral column in mammalia.

H. K. MOOKERJEE, Calcutta.

Primarily the notochord remains as a straight solid naked rod of cells with uniform diameter. Segmentally perichordal rings are formed round the notochord from the cells of both sclerotomites. The elastica externa makes its appearance by this time and the cytoplasm of the chorda cells forms the fibrous sheath of the notochord. The spaces between the successive perichordal rings are filled up by the sclerotomic cells (centrum rudiment) from both the adjacent sclerotomites. The notochord becomes dialated in the vertebral region and constricted in the intervertebrals. The perichordal rings together with the cells of the centrum

rudiments constitute the perichordal tube. The cells of the belt like centrum rudiments are differentiated into two concentric rings at a certain stage but this character does not persist throughout life. The nuclei of the notochordal cells instead of forming notochordal epithelium form a central mass, which with the chondrification traverses to the inter-vertebral dilatation of notochord and develops into nucleus pulposus. From the anterior and posterior parts of the perichordal rings the epiphysial plates of the vertebra are formed and intervertebral fibrocartilaginous bodies are formed from its middle portion. The anterior half of the perichordal ring is formed from the interdorsal and interventral components of the cranial sclerotomite and the posterior half from the basiventral or its outgrowth parapophysis. On being chondrified and ossified the centrum rudiments form the middle part of the adult centrum. The two epiphysial plates are formed from the anterior and posterior parts of the perichordal ring, which fuse with centrum rudiment.

The basidorsal and basiventrals never take part in centrum formation. The neuro-central suture or joint is present between basidorsal and centrum. The neural spine is formed by the fusion of the extensions of the basidorsal of the opposite sides over the spinal cord. The neural arch anterior to the neural spine is completed by the supradorsal element. The zygapophyses are formed by the anterior and posterior outgrowths of the adjacent basidorsals.

Proatlas is present between atlas and occipital region of skull. Its basidorsal unites with that of atlas and its centrum with the centrum of atlas. The atlas centrum in turn unites with axis centrum to form the odontoid. The proatlas basiventrals and perichordal ring become fused with basioccipital. The occipito-atlantic joint is segmental and inter-vertebral. Atlas ring is formed by basidorsals, basiventrals and by a strand of cells lying between the ends of basiventrals.

The basiventrals in the thoracic region do not chondrify and ossify. In the tail region only basiventrals ossify wholly and in the cervical vertebrae only the bases of them chondrify and ossify.

The capitulum of the cervical rib is attached with the basal part of the basiventral. And in thoracic region the capitulum attaches with a fibro cartilaginous strand running dorso-laterally in the posterior part or perichordal disc. The tuberculum is secondarily connected with the diapophysis and the connection is ligamentaous. The chondrification and ossification of the rib begin from the peripheral part of the rib.

57. A visit to some mountain lakes in Kashmir for faunistic study.

G. MATTHAI, Lahore.

The paper gives an account of a visit by a Party of Research workers from the Department of Zoology, Punjab University, Lahore, in the summer vacation of 1940, to some of the mountain lakes in Kashmir for the study of their fauna. Seven lakes in the region of the Liddar Valley were visited, viz., Shesh Nag, Sona Sar, Tar Sar, Chanda Sar, Dudh Nag, Sona Sar (Rewll) and Handil Sar. Over fifty species belonging to several invertebrate and vertebrate groups are represented in the collections.

58. The supposed genetic relationship of the Golgi apparatus and mitochondria.

D. R. BHATTACHARYA *and* MURLI DHAR LAL SRIVASTAVA, ALLAHABAD.

The 'Apparathülle' or the cortical portion of the Golgi Complex is not composed of 'Plastosomes' modified or as such, as Yamasaki gives us to understand (1936). On the contrary, the whole of the Golgi apparatus must be considered to be a cellular 'organelle', absolutely independent

of any other inclusion that may be occurring at the same time. The 'Apparatinhalt' or the chromophobic portion of the Complex, likewise, must be considered to be independent of the neutral-red vacuoles, the latter never entering into its composition as an ingredient, although they may be found in this zone after intra vitam or supra vital staining.

The neutral-red granules brought to view as a result of supra vital or intra vitam staining do not really exhibit any particular affinity to silver nitrate or osmic acid, and their subsequent metallic impregnation (Yamasaki, 1932 and 1936), which is effected with difficulty, must be considered to be brought about by the prolonged action of osmic acid or silver nitrate on the dye resulting in the production of a black precipitate. The entire conclusion and generalization of Yamasaki (1932, 1934, 1936) in this connection must be considered as hasty and lacking in proof.

The cells lining the uriniferous tubles of the frog which have been examined in this connection contain filamentous and granular mitochondria, which do not show any genetic relationship with the reticular Golgi apparatus. The neutral-red vacuoles are discrete bodies found to occur in the region occupied by the Golgi apparatus.

SECTION OF ENTOMOLOGY

President :—RAO BAHADUR Y. RAMCHANDRA RAO, M.A., F.R.E.S.

Biology of Insect Pests: their Control

1. Preliminary studies on the cardamom thrips—*Taeniothrips cardamomi* R., and its control.

M. C. CHERIAN *and* M. S. KYLASAM, Coimbatore.

A brief account of the cardamom thrips and its status as a pest of cardamoms is given. Information on the host and its environment is included. The nature and extent of damage, the distribution and the seasonal history of the pest are outlined. The thrips reaches peak infestation in May when the blossom flush is also heaviest. All the stages of the life cycle are passed on the host itself.

Experiments that were carried out would seem to indicate that it may be possible to reduce the scab injury by controlling the thrips with toxic sprays of tobacco decoction containing 0·28% nicotine.

2. Details of a severe infestation of *Schoenobius incertellus* W. on Kole paddy in Cochin, in January 1940.

C. S. VENKATASUBBAN, Cochin.

A seasonal crop which is usually immune to a particular pest, may sometimes suffer greatly, when, owing to climatic and environmental changes, the insect suddenly turns its attention towards it. An interesting instance is afforded by the severe out-break of the stemborer of paddy—*Schoenobius incertellus* W.– in the last 'Kole' crop of paddy, in Cochin, in January 1940. This is the first occasion, within the living memory of the Kole cultivators, that a severe infestation of the borer had taken place in this seasonal crop. The borer was so bad and widespread that many cultivators were under the impression that a supernatural blight had affected their crop. The main features of the infestation are detailed. The climatic and environmental disturbances that may have been responsible for the infestation are discussed. The control measures undertaken, as well as the subsequent subsidence of the pest are also recorded.

3. The Ber fruit fly—*Carpomyia vesuviana*, A. Costa, and its control.

M. C. CHERIAN *and* C. V. SUNDARAM, Coimbatore.

Carpomyia vesuviana A. Costa, is a serious pest of Ber (*Zizyphus jujuba*) fruits in Panyam, Kurnool Dist. Eggs are laid in the fruits and the maggots feed on the pulp and in due course pupate in the soil. The egg, larval and pupal stages are 2-3, 9–12 and 12–305 days respectively. The incidence of the fly is sometimes as high as 100 per cent. There are four to five broods in the year in Panyam. The fly has not been observed to breed on any other fruits so far. *Opius* (*Biosteres*) *carpomyiae* is found parasitic on the fly maggots. Of the large number of trees examined for

resistance to fly attack a few were observed to show only 2% incidence, while the neighbouring trees had cent per cent damage. Of the various methods of control tried, viz., poisoned molasses spray, use of essential oils and fruit fly lures and raking up of the soil to destroy the pupae; the last one was found to be the best.

4. Preliminary observations on the use of nicotine sulphate against citrus *Psylla*.

KHAN A. RAHMAN, Lyallpur.

Citrus *Psylla* is a most serious pest of citrus in the Punjab. It can be effectively controlled with rosin compound but the preparation of this insecticide demands skill and is laborious. Therefore, in order to simplify the control of this pest, various dusts have been under trial. Of these nicotine sulphate has so far given promise of success but is expensive.

The dust is prepared by mixing nicotine sulphate (40%) with such carriers as lime, ash and sulphur. The last-named carrier is more effective but its use increases the cost. A strength of 3½ to 4% nicotine sulphate by weight gave 92–97% mortality. At least two applications were found necessary for successful control of the pest. About 2 to 4 pounds of the dust was required per application for treating a single tree and it took 5 to 8 minutes to treat it with a hand duster. The cost was worked out at annas 3-6 to 8 per tree according to the carrier and the strength of the poison.

5. On an interesting case-bearing larva of a chrysomelid beetle.

MOHAN SINGH, New Delhi.

The paper contains an account of an interesting case-bearing chrysomelid larva of *Cryptocephalus* sp. The larva has been observed to feed on lucerne, '*bajra*' (*Pennisetum typhoideum*), cowpea and *Acacia*.

On hatching out of the egg, the larva retains the egg case supposed to have been made by the female with her excreta. When walking about in search of food it comes out of the case far enough to give free play to its legs dragging the case after it, with the posterior end always raised to an angle of about 75°. It continues to enlarge the case by the addition of bits of grass, but is incapable of rebuilding the case if it is deprived of it.

The paper also contains a description of the egg, the larva and the larval case and remarks on the larval parasitization by a chalcid parasite.

6. Habits and behaviour of the giant mealy bug (*Drosicha stebbingi*).

KHAN A. RAHMAN *and* ABDUL LATIF, Lyallpur.

The giant mealy bug (*Drosicha stebbingi*) lays eggs during May-June which, after a diapause of about eight months, hatch in January.

The food-plants of the pest were studied and it was found to feed on 44 plants and out of this lot, 24 plants are recorded here for the first time.

The nymphs show a great capacity for wandering in search of their host-plants. The first instar nymphs travel a distance of about 40 feet, while the last instar nymphs cover a distance of about 150 feet, to reach a suitable host.

The importance of weeds in the successful control of the pest was found by recording the population of the nymphs on 200 weeds in two adjacent gardens—one having trees banded with sticky material and the other with trees without any bands. In the former garden the average

population of nymphs per weed was 1,526 as against 430 in the latter garden.

Quiescent period of the nymphs was found to be 6–14 days before first moult, and 5–12 and 5–8 days before second and third moults respectively. The first instar nymphs and second instar male nymphs spent the period of quiescence gregariously in crevices, under bark, etc., of the plants.

G. R. Dutt (1926) had shown that in order to reach the soil the pest crawls along the limbs and trunks of an infested tree. We found that there was quite an appreciable number of the females which dropped to the ground directly from the tree. Dutt's control measures were critically examined in the light of this discovery.

7. Biology of the citrus leaf miner.

KHAN A. RAHMAN, Lyallpur.

Citrus leaf miner is a widely distributed pest in the Orient, for it has so far been recorded from India, Burma, Ceylon, Malaya, China, Japan, the Philippine Islands, and the Dutch East Indies; it has also been reported from Northern Australia and South Africa; in the Punjab it is present in almost all the citrus plantations.

The females lay eggs singly usually on the underside of fresh, tender leaves. They hatch in 2–10 days. The caterpillar mines the leaves and makes a silvery white zig-zag tunnel in which it lives: the caterpillar is full-fed in 5–30 days. Pupation takes place in the mine in a cocoon. The pupal stage occupies 5–25 days.

The attack of the pest is severe at two different parts of the year, once in April-May and then again in August. The attacked leaf remains stunted in growth, is deformed, becomes yellow and ultimately drops off.

8. Migration of *Chilo trypetes* Bisset, from the top portion of sugarcane to its roots for hibernation.

KHAN A. RAHMAN, Lyallpur.

Chilo trypetes Bisset, is a new and specific pest of sugarcane which has been recently discovered in the Punjab. It is limited in its distribution and has so far been recorded at Gurdaspur, Mukerian, Sialkot, Batala and Pathankot. It is active during July–September when it passes through three generations. As a caterpillar it lives in the tunnel which it makes in the cane and which extends from the point of its original entry upwards. During this period the first two generations complete their life-cycle in the top portion of the affected cane but the full-fed caterpillars of the third generation migrate to the roots of attacked or healthy plants for hibernation. For this purpose they come out of the tunnel, crawl along the stem and bore into it 2″–3″ above the ground and thus enter the roots. But, if, during their migration, they are blown off the plant by wind or any other agency, they bore into the lower portion of any cane to enter the roots.

9. Feeding habits of *Urostylia punctigera* Westw. (Pentatomidae, Rhynchota) and damage done to *Michelia champaca* in Bengal.

N. C. CHATTERJEE, Dehra Dun.

Michelia champaca (Champ, Champa) is one of the most important timber species in Bengal and considerable areas have been planted in North Bengal and Dooars forest divisions. Since 1927 the champ bug *Urostylis punctigera* Westw. has become a pest of considerable importance

to the growth of champ, as a massed attack of the bug is able to kill and wipe away young plantations outright. The vital damage to champ is caused by the piercing and sucking of sap from newly formed leaves and young shoots by the bug while feeding, as a result of which the foliage wilts and dies back.

Full details of the nature and extent of damage are given.

10. Notes on a Microlepidopterous borer on sapota fruits in Cochin.

C. S. VENKATASUBBAN, Cochin.

Sapota—*Acras Sapota*—fruits in Cochin are found infested by a species of Microlepidoptera, which is not definitely identified. The moth lays eggs singly on the surface of the fruit. As soon as the larva hatches, it burrows into the fruit, and remains feeding on the pulp inside. When full-grown the caterpillar pupates within a flimsy cocoon of silk, inside a chamber in the fruit, which has an opening towards the exterior for the exit of the moth. All sizes of fruits are attacked, but the incidence is generally more marked in the middle-sized fruits. The attacked fruits do not fall down. The borer attack is more evident during the months of May, June and July.

11. Biology of *Bruchus chinensis* L.

KHAN A. RAHMAN, A. N. SAPRA, *and* G. S. SOHI, Lyallpur.

Bruchus chinensis L. is a serious pest of stored grams in the Punjab.

It is active during April–October. It spends the period from November to March in hibernation, usually as a grub, inside a gram.

The females lay 34–111 eggs at the rate of 1–37 eggs per day in 5–17 days. The eggs are laid singly glued to the surface of the gram. The eggs hatch in 4–13 days. The larvae on hatching bore into the seed and there may be as many as three larvae in one. The larva is full-fed in 10–29 days. It pupates in the gram near its coat. The adult emerges after 6–9 days by cutting a circular hole in the shell.

12. Biology of *Bruchus analis* F.

KHAN A. RAHMAN, G. S. SOHI, *and* A. N. SAPRA, Lyallpur.

Bruchus analis F. is a serious pest of stored 'Moong' (*Phaseolus mungo*), 'Moth' (*Phaseolus aconitifolius*) and 'Mash' (*Phaseolus radiatus*) and 'Rawan' (*Vigna catiang*) and, in the Punjab, it has so far been recorded from Lyallpur and Sheikhupura. The adults which are very active, are capable of fairly strong flight. The larva on hatching bores into the seed and feeds on its contents. By the time it attains its complete development, the contents of the seed are entirely consumed leaving only the shell or seed-coat behind. The adult emerges by making a circular hole in the shell. Since several generations are passed in quick succession in a season and a single grub is capable of destroying a whole grain, the infested stock is reduced to a mass of hollowed out grain in a comparatively short time. In an advanced stage of insect attack, a fungus also appears in closed receptacles which imparts to the grains a very foul smell.

Copulation takes place immediately after emergence and the pair may remain in coitus for 2·75 to 17·6 minutes. 1–3 days after copulation the females start oviposition and lays 23–150 eggs at the rate of 1–82 eggs per day in 2–8 days. Eggs are glued on to the grain, usually one egg on each grain. Eggs hatch in 6–9 days in April and 3–5 days in May–August. The larva on hatching bores into the seed and passes its entire existence within it feeding on its contents. It

becomes full-fed in 8–27 days when it comes to lie next to the seed-coat where it turns into a pupa. Pupal stage lasts for 5–13 days and the adults emerge by cutting a circular hole in the seed-coat. The females live for 3–7 days and the males for 3–11 days.

The larva of the pest is parasitized by *Bruchobius laticeps* Ashm.

13. San Jose' scale in the Punjab.

KHAN A. RAHMAN, Lyallpur.

San Jose' scale is a serious pest of deciduous fruit trees, and shade and ornamental plants. Its original home is China from where it was taken to U.S.A. in 1870. By 1921 it had become established in almost all the apple growing tracts of the world. In the Punjab it was first discovered in 1923 at Kulu. Subsequent search revealed it in the Simla hills, Kulu Valley, Murree hills and Dalhousie.

It can live on the sap of about 180 different kinds of plants. Among the plants which suffer most from its attack are apple, pear, peach, plum, cherry and their closely related wild species, currant, willow, hawthorn and rose.

San Jose' scale passes the winter as nymph underneath a dark grey or black scale on the trunk, branches and twigs of its food-plant. Such scales are also present in the eye and navel of ripe fruit sold in fruit markets. These nymphs resume feeding in March. Males emerge in March-April, mate with the females and then perish. Nymphs appear in May. Male nymphs reach maturity in 25–30 days while female nymphs take 30–35 days to mature. The pest keeps up active reproduction up to November-December when hibernation begins. There are 4-5 generations in a year.

The pest is spread most commonly through nursery stock.

It kills a young plant in 2-3 years and an older one in 4-5 years.

It can be effectively controlled with fuel oil emulsion which is composed of 5 seers of diesel oil, 2 seers of potash vegetable soap and about 14 seers of water. One part of this emulsified material is diluted with 33 parts of water and sprayed on the attacked plant.

Ecology

14. Effect of plant colour on the body coloration of the desert locust (*Schistocerca gregaria*).

DES RAJ BHATIA, Barmer (Rajputana).

Field observations on the desert locust, *Schistocerca gregaria*, show that ordinarily the body colour of hoppers (as well as adults) assimilates the colour of the plants on which they live. For instance a hopper on 'bajra' (*Pennisetum typhoideum*) has green colour and one found on 'booh' (*Aerua javanica*) has greenish white or ashy blue colour. Hoppers found among dry grasses become hay coloured.

Whitish green body colour is supposed to be characteristic of the freshly moulted solitary adults, but it has been observed that in cases they are found among green vegetation even the sexually mature forms may develop green body colour. This is obviously a secondary development presumably due to the nature of the surrounding vegetation.

15. Colour variation in some lepidopterous larvae of economic importance.

MOHAN SINGH, New Delhi.

The paper deals with colour variation due to the difference in the nature and colour of the food observed in the larvae of ***Heliothis armigera***

Hb., *Laphygma exigua* Hb., *Antigastra catalaunalis* Dup., *Margaronia indica* Saund., *Plutella maculipennis* Curt., *Euchrysops cnejus* Fb., *Marasmia trapezalis* Guen.

It has been observed that the ground colour of the larvae is largely dependent upon the colour of the food though the colour patterns proper to the larvae are independent thereof; for example, larvae of *Heliothis armigera* when fed on pink petals of holly-hock flowers develop pink colour, though the colour patterns proper to the species remain unaltered. In the case of *Antigàstra catalaunalis*, larvae when fed on green leaves, develop uniformly green colour and pinkish blue when fed on petals of *Sesamum indicum*. So also in *Plutella maculipennis*, larvae when fed on green leaves of cabbage remained green, but when fed on purple leaves developed purple colour.

In order that the food should have the fullest effect on the colour of the larvae, they must be fed on that food (plant) from their very birth or else intermediate shades will result.

16. The seasonal incidence of the fruit flies, *Dacus cucurbitae* Coq. and *Dacus ciliatus* Loew at Delhi.

HEM SINGH PRUTHI, New Delhi.

Amongst the species of fruit flies infesting cucurbits in India *Myiopardalis pardalina* Bigot and *Dacus cucurbitae* Coq. are recognized as serious pests, the former species attacking melons and the latter infesting besides melons, several other cucurbits, e.g., *Momordica charantia* (Karela), *Luffa aegyptiaca* (tori), gourds, cucumber, etc.

During the last three years the well-known Ethiopean fruit fly, *Dacus ciliatus* (*D. brevistylus* Bezzi) has been found causing serious damage to cucurbits along with *D. cucurbitae* at Delhi.

Field observations on the seasonal prevalence and relative incidence of the above two species of *Dacus* indicate that each species requires specific environmental conditions for favourable breeding. Whereas year after year *D. ciliatus* appears about the beginning of June and infests 50 per cent of melon fruit by the end of that month, the time of appearance of *D. cucurbitae* has been found coinciding with the first shower of monsoon rains which may be at the end of June or early in July. The melon crop is, therefore, mostly attacked by *D. ciliatus*. During rainy and winter seasons there is a mixed infestation by both the species, the intensity of attack ranging from 70 to 90 per cent in *karela* and *tori*. Field collections and records of rearing of flies from infested fruits have shown beyond doubt that during the rainy season the attack is chiefly caused by *D. cucurbitae* whereas in winter the incidence in fruits is mainly due to *D. ciliatus*.

Thus it is concluded that the fecundity of *D. ciliatus* is adversely affected by increased humidity and therefore the damage by this fly is expected to be serious in dry summer and winter. On the other hand, extremes of weather do not seem to be favourable for the breeding of *D. cucurbitae* and the species would increase in numbers and be a serious pest in hot and moist weather.

17. On the fatal temperatures for the pink bollworm (*Platyedra gossypiella*) of cotton.

HEM SINGH PRUTHI *and* TASKHIR AHMAD, New Delhi.

The method of controlling the pink bollworm by preventing the 'carry-over' of the hibernating larvae found inside the harvested seed by suitable heat treatment has been followed in some countries and recommended for adoption in certain parts of India. Yet few accurate data on lethal temperatures and humidities for the bollworms themselves (outside the

cotton seed) and for the seed are available under Indian conditions. At the request of the Department of Agriculture, United Provinces, this investigation was taken up last year and the results of the work carried out so far are summarized here:—

Hitherto almost all the workers have subjected bollworms resting in cotton seeds to various temperatures. It is obvious that the value of such results is limited as the effect of these exposures would vary widely with the temperature and moisture content of the seeds before and after treatment, the texture and fuzziness of the seed, the prevailing relative humidity, etc. Thus the heat tolerance of naked larvae taken out of the seeds is of fundamental importance in the study of heat treatment as a control measure.

Our experiments have shown that naked larvae undergo complete mortality when exposed for 24 hours to 45°C., 1-2½ hours to 50°C., 7-10 minutes to 55°C., 5 minutes to 65°C. or one minute to 70°C. If instead of naked larvae the cotton seeds containing larvae are treated and are brought from and taken to a room temperature of 35°-40°C., an exposure of over 3 hours to 50°C., 40 minutes to 55°C., 15 minutes to 60°C., 7-10 minutes to 65°C., or 3-5 minutes to 70°C., is completely fatal to larvae within the seeds. Thus from practical point of view where time factor is of considerable importance in dealing with large quantities of material, the exposure of seeds to heat should be so regulated with reference to the initial and final seed temperature and the nature of seed, etc., that the larvae themselves inside the seeds are at a temperature of 65° to 70°C. for one to two minutes.

The part played by atmospheric moisture in determining larval mortality at different high temperatures was hitherto little explored. We have now determined that under relatively dry conditions the larvae resist high temperatures better and therefore longer exposures would be required to ensure complete mortality. For instance, while an exposure of seeds for 24 hours to 45°C. is completely fatal to larvae if the saturation deficiency of air is 3-14 mm., it is not fatal if the saturation deficiency is 32 mm.

Experiments on the protection afforded by the variety of cotton seed to the larvae inside them during heat treatments were conducted only on two varieties, viz., a *desi* variety (Mollisoni) and an American variety (289F.). It has been found that although the difference is not great, yet the heat treatment remaining the same, there was always higher mortality among larvae inside American seeds as compared to those inside *desi* seeds.

The viability of cotton seeds is not affected materially up to an exposure of about 20 minutes to 65°C. or 15 minutes to 75°C. or 7 minutes to 80°C. This shows that there is a fair margin of safety between heat exposures fatal to larvae and those injurious to the viability of the seeds. It must be pointed out that in practice the seeds after coming out of the hot machine retain heat for some time, particularly if they are put into sacks immediately after treatment and this period must be kept in view while prescribing temperature and exposure.

The technique of heat treatment is discussed.

18. Studies on bee behaviour.

M. C. Cherian, S. Ramachandran, *and* V. Mahadevan, Coimbatore.

Flight activity of honey bees and the corresponding fluctuations in the weights of the colonies were studied in relation to the environments such as availability of bee pasturage, atmospheric temperature, relative humidity, etc. Some interesting observations on the factors influencing bee activity, the response of the bees to the characteristic weather and pasturage conditions prevalent during the different seasons of the year as

well as to the variations occurring from hour to hour within the day, are recorded. Statistical correlations between the availability and collection of the bee foods and the external conditions are presented.

19. The relationship between the distribution of the Ox Warble-fly (*Hypoderma lineatum* De Villers) and soil moisture in India.

B. N. SONI, Mukteswar.

Soil moisture has an important bearing on the life-history of *Hypoderma lineatum*. During the period, when the pupa has to remain in the soil for nearly six weeks, any excess of soil moisture has a detrimental effect on its development. Experiments carried out in the laboratory at Mukteswar have shown that the maximum number of emergences occur at soil moisture varying from 1 to 5 per cent and that no emergences occur in the case of pupae kept at a soil moisture of 15 per cent and above. These observations in the laboratory are in accord with those made in the field regarding the distribution of the Ox Warble-fly in India. Various workers in the United States of America have arrived at similar conclusions as a result of experiments conducted in the field and laboratory.

20. Experiments on the pupa-formation of the moth, *Prodenia litura* Fb. (Lepidoptera, Noctuidae) in relation to its different environment.

D. P. RAICHOUDHURY *and* A. C. BASU, Calcutta.

The paper deals with the pupa-formation of the moth *Prodenia litura* Fb. (Lepidoptera, Noctuidae) under different environmental conditions. The transformation of the pupae in *P. litura* occurs under the earth surface as well as under other substrata. Pupation cannot take place on an open surface without any substratum. The late larvae bore their way into the neighbouring substrata probably for prepupal safety and for securing immunity from any appreciable degree of temperature changes. The substrata endowed with sticky secretions give extra facility in building up the prepupal cases. The percentages of pupae formed depend on the types of the substrata as well as on the capacity of the late larval instars in perforating the surface of the substratum concerned. Hard and disturbed substrata cause an adverse effect on the percentage of pupa formation; and in soft and undisturbed substrata, the percentages of pupation is higher; but a very soft substratum is not at all helpful to the larvae for transforming into pupae. Darkness alone has no effect on the pupa-formation of *P. litura.*

Insect Vectors of Virus Diseases

21. Some new alternate hosts of tobacco leaf-curl disease and the insect vector concerned.

HEM SINGH PRUTHI *and* C. K. SAMUEL, New Delhi.

At some previous sessions of the Indian Science Congress (1938 and 1939) the question of the transmission of leaf-curl virus from diseased sannhemp and *Ageratum conyzoides* to healthy tobacco by the agency of white-fly, *Bemisia gossypiperda*, was discussed. Experimental work carried out during the last two years has revealed a large number of other alternate food-plants of the white-fly which suffer from leaf-curl disease and from which the white-fly can transmit the disease to healthy tobacco. In the case of the following plants transmission experiments have given

over 50% positive results:—*Zinnia elegans, Solanum nigrum, Euphorbia hirta, Vernonia cinerea, Lycopersicum esculentum.* With *Launea asplenifolia, Sida rhombifolia* and *Scoparia dulcis.* between 40 and 50 per cent positive results were obtained.

As regards the actual sources of leaf-curl infection to tobacco in the field, it does not necessarily follow that all the plants named above are sources of danger to this crop. To determine the real sources, one has to consider the time of the year when the above plants occur in the field and the time when they show the incidence of the disease, remembering that tobacco is most susceptible to infection and damage from September up to the end of November. Though our experiments reported in the present paper show that tobacco can get infected during spring (February-March) also, if it is not more than about ten weeks old, it is only of academic interest as in actual practice the tobacco crop in North Bihar is generally harvested in January-February and if it is still standing, only young leaves of the offshoots get diseased.

It is noteworthy that with another species of white-fly, viz., *B. giffardi*, which is also common at Pusa, no successful transmission was obtained in the case of any plant. In fact it did not feed on tobacco at all.

Natural Enemies of Insects

22. Beetles predatory on the sugarcane white-fly—*Jauravia* sp. ?

M. A. H. Qadri, Aligarh.

Several species of beetles have been collected feeding on the pupae of sugarcane white-fly *Aleurodes barodensis* at Aligarh. Out of these two coccinellid beetles *Brumus suturalis*, Fab. and *Jauravia* sp. are especially conspicuous for their fixed habits and the consumption of larger number of white-fly pupae. The studies on the bionomics of *B. suturalis* are at present in preliminary stage. The facts about the biology of *Jauravia* are, however, more fully known and will be briefly recorded below.

The first appearance of this beetle takes place synchronously with the appearance of the pupae of white-fly near about the middle of the rainy season. This year (1940) it was captured in the fields for the first time after the rains at the end of the third week of August. The beetle disappears for aestivation at the beginning of summer when the white-fly also vanishes. The adults are dark-red shining beetles. Their bodies are convex and spherical. They are more or less sluggish and do not fly unless disturbed. They feed on the pupae of white-fly but their rate of consumption is much lower than that of the larvae.

Eggs :—

Eggs are laid on the sugarcane leaf in clusters of 6–8. They are white in colour and are sub-spherical.

Larvae :—

The larvae are whitish grey in colour. They are very active and feed voraciously on the pupae of white-fly. They are typical campodeiform larvae but are without cercal appendages at the posterior end of the body. The larvae exhibit a peculiar gregarious habit particularly in their early stages and are found to moult together in large numbers. The larvae become quiescent a few days before pupation.

Pupa :—

The pupa is of the usual coccinellid type with a broad cephalothoracic region and a narrow abdomen. The pupal stage lasts for 4 to 5 days. Towards the end of the pupal stage the pupa gets pinkish and ultimately

dehisces along the mid-dorsal line in the region of thorax for the emergence of the adult.

23. Biological notes on *Sinoxylon sudanicum* Lesne and its parasites in South India.

P. N. KRISHNA AYYAR *and* V. MARGABANDHU, Coimbatore.

In the course of an investigation into the possibilities of biological control of *Pempheres affinis* Fst. it was discovered that *Sinoxylon sudanicum* Lesne constituted a useful and abundant alternate host for an important Pempheres parasite, namely *Spathius critolaus* Nixon. While attempting to utilize this host for the mass breeding of this parasite, some observations on the biology and habits of the insect were made. An account of these observations is presented in this paper.

These insects are commonly found boring into the stems of Cambodia cotton slightly weakened by other causes in the field, particularly in the season November to January. They also heavily infest these plants in storage after removal from the field. Their habits, activities, course of tunnelling and preference for this food plant are discussed. Their activities are at the maximum late in the afternoon on bright sunny days. The life-cycle approximately ranges from 43 to 53 days. There appear to be four distinct generations of the insect under South Indian conditions. Brief references to the parasites and predators of the insect are also included.

24. Biology of the Reduviid bug, *Acanthaspis quinquespinosa* (Fabr.), an enemy of white-ants.

HEM SINGH PRUTHI, New Delhi.

Reduviid bugs are mostly beneficial insects as they prey upon a large number of injurious insects. In India, very little is known about the habits and bionomics of this family.

A. quinquespinosa (Fabr.) is a widely distributed species previously recorded from Khasi Hills, Ranchi, Saran, Poona, Bhore-Ghat, Ceylon and Burma.

The nymphs and adult of this bug were found feeding at Delhi on white-ant workers and inhabiting localities where white-ant galleries are present. Winter and early spring are passed as nymphs and adults. About the end of March the nymphs become adults and copulation and oviposition commence. The eggs laid during this period aestivate throughout May and June and hatch when the monsoon rains break out.

The eggs are laid singly in the laboratory under pieces of paper or moist earth, specially the latter. The oviposition period extends over a month and 150–200 eggs are laid by a single female.

The nymphal period is 52 to 65 days during July to September. During winter they hibernate in the 4th and 5th instars and the nymphal period thus extends from about the beginning of October to February or March. The nymphs have the peculiar habit of disguising themselves by covering their bodies with various substances such as cast-skins, pieces of paper, wood, charcoal, soil particles and the skeletons of the white-ant workers which are held in place by means of sticky hairs present on their body. With each moult the material is thrown away and fresh material is gradually put on with the help of the hind pair of legs.

There are 1-2 generations in a year. The activity of the bug synchronises very well with the activity of white ants. The white-ants are active during spring, rainy season and autumn and so is the bug.

Considering their longevity and voracity for food, an immensely large number of white-ant workers may be destroyed by each nymph. They also readily feed on pink and spotted bollworms of cotton if offered in the laboratory.

25. The biology of *Amyosoma chilonis* Viereck—a larval parasite of *Chilo zonellus* Swin.

M. C. Cherian *and* P. S. Narayanaswamy, Coimbatore.

The Pyralid moth borer—*Chilo zonellus*, Swin.—a major pest of Sorghum in the Madras Presidency, is subject to the attack of a number of parasites of which *Amyosoma chilonis* Viereck is one. The parasite lays eggs loosely in a cluster on any part of the body of the host ranging from one to a dozen in number. The maximum number of eggs laid by a single female is 84. The egg hatches in a day. The larva feeds on the host and attains full growth in 3 days when it spins a cocoon. The prepupal stage extends from 3 to 4 days and the pupal stage 5 to 7 days. The total life-cycle of the parasite is 12 to 15 days. The adult is fairly long lived, the maximum longevity being 59 days. Parthenogenesis is a common phenomenon, the progeny in this case being all males.

The description of the various stages, the habits of the parasite, its alternate hosts and efficacy in controlling the borer pest are discussed in the paper.

26. *Rhaconotus caulicola* Muese. (Hym. Brac.), a larval parasite of the sugarcane white moth borer (*Scirpophaga rhodoproctalis*, Hmps.).

M. C. Cherian *and* P. Israel, Coimbatore.

Rhaconotus caulicola Muese of which the biology is given in this paper is new to science and occurs as a larval parasite of the moth borer *Scirpophaga rhodoproctalis* Hmps. in sugarcane. Its habits are described as also its life-history. The seasonal and regional prevalence has also been studied. Its efficacy as a parasite is broadly indicated.

Taxonomy and Faunistic Studies

27. The relationship of *Microbracon hebetor* Say and *M. brevicornis* Wesmael.

K. B. Lal, New Delhi.

The parasites, *Microbracon hebetor* Say and *M. brevicornis* Wesmael, are cosmopolitan species, attacking a large variety of Lepidopterous hosts in various parts of the world. In India there have been very few references to them and the parasites were not considered of much importance till 1936 when Glover and Chatterjee reported the occurrence of *M. hebetor* at Namkum, Ranchi, and found it parasitizing *Eublemma amabilis* Moore, *Holcocera pulverea*, Meyrick and *Eublemma scitula*, Rmbr. in the laboratory. The authors suggested, therefore, the potential use of *M. hebetor* in the biological control of the predator enemies of the lac insect but considered the species to be rare in northern India, a statement, which, in effect, was contradicted by Ghulamullah (1939) speaking for areas near about Delhi. Some doubt has also arisen about the correct identity of *hebetor* as distinguished from *brevicornis*, which also has been known to occur in northern India, specially in view of the conflicting opinions held on the relationship of these two species by some European and American workers. The question of the identity and distribution in India of these two species has, therefore, assumed considerable economic importance. In the present contribution the extreme similarity of the two species, *hebetor* and *brevicornis*, is emphasized and the existence of some intermediate and aberrant forms in specimens reared from various hosts at New Delhi is pointed out as introducing complications in the otherwise easy separation of the two species, which, for the present, are

allowed to remain distinct, although it is suggested that at a later stage they may have to be merged into one species with possibly two or more biological or geographical races.

28. The status and study of the 'Thysanoptera' of India.

T. V. RAMAKRISHNA AYYAR, Madras.

Among the different groups of insects inhabiting the various tracts of India, the order Thysanoptera forms one of the divisions the study of which has been greatly neglected till now. In this brief paper an attempt is made to invite the attention of young entomologists in India to this unexplored field of Entomology. In doing so the peculiar and unique structural and bionomic characteristics of these insects which stand in need of a good deal of investigation are pointed out. The structure and functions of their mouth parts, legs and wings as compared with all other groups of insects are features which deserve the attention of future workers. In addition their importance from various economic aspects as crop pests, plant disease vectors, blood suckers, flower pollinators and weed killers also call for a good deal of attention from economic entomologists. The very unsatisfactory and meagre systematic work done on Indian Thysanoptera until lately is also referred to in the paper.

29. Dung fauna studies at Lyallpur.

KHAN A. RAHMAN, A. N. SAPRA, *and* G. S. SOHI, Lyallpur.

The work on dung fauna has been in progress for the last two years. During this period sixty-seven species of insects consisting of 29 species of Diptera, 12 species of Hymenoptera, 20 species of Coleoptera, 2 species of Collembola, 1 of Heteroptera and 3 of Arachnida were collected.

These insects are active throughout summer but in winter only 2 species of Diptera and 2 of Hymenoptera are active.

The infestation in fresh dung when stored in a pit starts from the top and gradually works downwards: during the first fortnight of storage, the top three inches are mostly infested, but during the second fortnight the infestation spreads down to 3″–6″ while after a month or so, the deeper layers get infested.

30. Staphylinidae from Lyallpur.

KHAN A. RAHMAN *and* M. A. GHANI, Lyallpur.

Out of 133 of the Punjab Staphylinid beetles mentioned in the fauna of 'British India', 131 are recorded from the hilly tracts of Simla, Kulu and Murree and only two are recorded from the plains (Lahore and Shahpur). This numerical disproportion between the hill and the plain species in a continuous area shows that the plains had been searched only cursorily. This group, however, is of great economic importance in view of the known propensities of its members for feeding on other insects and it was, therefore, decided to make a collection of them and study their habits at Lyallpur. The following 22 species were collected and their habits studied.

Creophilus vittipennis Kr., *Staphylinus* sp., *Indoscitalinus anachoreta* Er., *Leptacinus parumpunctatus* Gyll., *L. parumpunctatus* Gyll. var. *tricolor* Kr., *Philonthus delicatulus* Boh., *P. thermarum* Aube., *P. speciosus* Cam., *P. cinctulus* Gr., *P. gemellus* Kr., *Leucoparyphus limbifer* Mots. var. *marginicollis* Kr., *Paederus fuscipes* Curt., *Trogophloeus (Boopinus) siamensis* Fauv., *Aleochara clavicornis* Redt., *A. trivialis* Kr., *Oxytelus (Caccoporus) ferrugineus* Kr., *Oxytelus (Anotylus) latiusculus* Kr., *Platys-*

tethus cornutus Gr., *Atheta nigerrima* Aube., *A. nuberula* Klug., *A. ghanii* Cam., *Ocypus bicolor* Cam., *Myrmecopora elegans* Cam.

31. Some observations on the insect life of the Liddar valley, Kashmir.

D. R. PURI, Lahore.

The present paper is based on a collection of insects made by the author when he accompanied a Research party from the Zoology Department of the Punjab University to Kashmir, during the summer of 1940.

The commoner and larger insects were collected, and observations made in the field were recorded.

The collection includes approximately 200 species belonging to various orders of insects.

Observations made in the field mainly refer to the ecology and geographical distribution of the species collected.

32. Mallophaga from *Gallus domesticus*.

KHAN A. RAHMAN *and* A. R. ANSARI, Lyallpur.

In the Punjab *Gallus domesticus* is attacked by about nine different species of Mallophaga, viz., *Menopon pallidum* Nitzsch., *M. stramineum* Nitzsch., *Lipeurus tropicalis* Peter., *L. heterographus* Nitzsch., *L. variabilis* Nitzsch., *Goniodes dissimilis* Nitzsch., *Goniocotes hologaster* Nitzsch., *G. gologaster* var. *maculatus* Tasch., and *G. gigas* Tasch. The more important of these are briefly discussed below:—

(1) *Menopon pallidum* Nitzsch.—This is the commonest of the lice which is present throughout the year on *G. domesticus*. It is of light-straw colour and crawls about actively among the feathers of its host.

(2) *Lipeurus heterographus* Nitzsch.—This lice is of fairly common occurrence in the Province. It is smoky in colour and abounds on the neck and head of the host.

(3) *Lipeurus variabilis* Nitzsch.—It is a dirty white lice which infests the primary and secondary feathers of the wings.

(4) *Goniocotes gigas* Tasch.—This lice is also fairly common but is usually never abundant on a bird. It is a large-sized species which abounds on the back of the host.

The life-history of *L. heterographus* was studied in detail. A female was found to lay 14–26 eggs in her lifetime. The eggs hatched out in 5–8 days and the nymphs took 26–34 days to reach maturity.

Morphology, Physiology and Development

33. On the post-embryonic development of the male genital organs of *Dryinus* (Hymenoptera).

R. RAKSHPAL, Lucknow.

An account of the internal genital organs and the external genitalia and their development is given.

The genitalia are paired in origin and represent the coxites and teleopodites of the ninth segment.

The whole of the efferent system is also paired in origin. The efferent system, except the ductus ejaculatorius and the paired ejaculatory ducts, is mesodermal in origin. The gonophore is situated posteriorly to the ninth segment.

34. Preliminary observations on the morphological changes following growth and differentiation of the various phases of the common mound-building termite *Termes redemanni* Wasm.

D. MUKERJI *and* S. RAICHOUDHURY, Calcutta.

Specimens of various phases commencing from the egg to the deälated stage of the common mound-building termite *Termes redemanni* Wasm., were collected at different seasons from Halisahar, thirty miles distant from Calcutta, and the habits, development and morphology of the species are being studied. In this paper morphological changes following growth and differentiation of sexual and non-sexual phases are recorded. Special attention has been paid to the comparison of the mouth-parts of worker, soldier and queen commencing from the immature forms with eleven jointed-antenna to the forms with eighteen jointed-antenna.

The worker and sexual phases conform in their mouth-parts closely to the immature forms, while the mouth-parts of the soldier become differentiated from the rest at the penultimate stage. In the digestive system the histology of which has been studied, the soldier differs from other phases in having a pair of glandular tubules opening into the terminal ends of the projecting labrum. The tubule is swollen at the posterior end occupying the trunk; it is filled with a creamy white substance. Sexual glands are first noticeable in forms with wing pads but no trace of them could be found in earlier stage of the wingless forms.

In queens, two of which occur in the same chamber in a single nest, ovarioles form a dense mass of entwined threads and are of panoistic type.

35. The growth of insect antenna.

M. A. H. QADRI, Aligarh.

The growth of the antenna of insects has been regarded to take place by means of two processes. Firstly, there is an increase in the size of the individual joints of the antenna and secondly, the number of the antennal joints increases during the post-embryonic growth of insects. The second process, viz., the increase in the number of antennal joints has been subject to a difference of opinion. Lubbock in Ephemeroptera held that the increase of the antennal joint takes place by the sub-division of the distal joints of the antennae. Others—Fuller (Termites), Bugnion (*Periplaneta orientalis*), Ide (Ephemeroptera) and Qadri (*Blatta orientalis*)—have shown that the third antennal joint forms the zone of joint-multiplication in insects. The following is an abstract of the observations made on the growth of the antennae of exopterygote insects.

The antennae of the above-mentioned forms fall into two types. First, those in which the flagellum consists of a large number of joints. Among such forms the number of the antennal joints of *Periplaneta* and *Blatta* have been observed to have become treble during the post-embryonic growth. The second type of antenna has a flagellum consisting of a much smaller number, and it has been observed in *Forficula* and *Locusta* that the number of joints of the antenna of adult is less than double that of the first instar nymph. These two types will be dealt with separately since they show different modes of joint multiplication. It is, however, essential to point out that in all cases the third antennal joint provides the zone of joint multiplication. It also serves, as Fuller says, as 'the womb' of the new joints since they undergo some growth and differentiation before their separation from it.

In insects with the antennary flagellum consisting of a large number of joints, studies were carried on *Blatta orientalis*, *Periplaneta americana*, *Gryllus domesticus* (Orthoptera), *Ephemera vulgata* (Ephemeroptera),

Nemoura variegata (Plecoptera) and *Machilis maritimus* and *Lepisma saccharina* (Thysanura). In these cases the growth and multiplication of joints take place as is described in *Blatta* by Qadri (*Bull. Entom. Research*, XXIX, 1938). The third antennal joint is divided into a large number of paired daughter joints which separate in pairs from the parent joint. Later on they grow and each of the pairs separates, and grows to form independent joint.

In insects with the antennary flagellum consisting of a small but fixed number of joints, studies were carried out on *Locusta migratoria* (Orthoptera) and *Forficula auricularia* (Dermaptera). In these cases as well, the third antennal joint is the parent of the new joints which are added during the post-embryonic development. The third joint in this case is divided into two or three sub-joints. These daughter joints grow and separate one by one from the parent joint.

36. On the alimentary canal of the larva of *Scirpophaga nivella* (Pyralidae: Lep.), with a discussion on the nature of the so-called goblet-cells in the mid-gut epithelium.

N. S. Aren, Lucknow.

The paper deals with the anatomy and histology of the larval alimentary canal of *Scirpophaga nivella.* Two new facts are emphasized: (i) that the stomodaeal invagination into the mid-gut does actually function as a valve and checks the re-entry of food-contents of the mid-gut into the fore-gut and was therefore correctly termed as the 'oesophageal valve', and (ii) that the so-called goblets in the mid-gut epithelium are not contained within the cells but are intercellular secretory globules contained in cavities formed by the invaginations of the epithelial border, so that there are no special epithelial cells which may be called goblet-cells.

37. The hypodermal glands of *Pulvinaria maxima* Green.

A. B. Misra *and* V. Prabhakar Rao, Benares.

The various kinds of hypodermal glands of *Pulvinaria maxima* are described in this paper. Unicellular and pluricellular wax-secreting glands are present in the dorsum and lie scattered all over it.

The unicellular gland possesses a large round nucleus and opens to the exterior through a circular pore lying in the centre of a less sclerotised area. These glands secrete wax in the form of small squamae.

The pluricellular glands are made up of six to nine cells, one of which is always larger than the rest and forms the base of the flask-like body. The cell boundaries are clearly defined in the fundus region of the gland, but less so in the neck region. The opening of these glands is similar to that of the foregoing type.

Unicellular glands are present all round the margin of the body of the insect in association with the marginal setae, and secrete wax in the form of cylindrical threads.

Unicellular glands also occur at the base of the stigmatic setae. These also secrete wax, since a pencil of wax exudes around each seta very much in the same way as in the case of the marginal setae.

Pluricellular glands of pyriform shape occur in the bay of the anal cleft. All the cells composing the gland are distinctly defined, and open independently to the exterior on a multilocular plate. These glands take an auxiliary part in spinning the ovisac.

Pluricellular glands, round in form and provided with simple lumen, lie in the submarginal zone of the ventrum of the insect. The gland is made up of three cells, which are displaced to the sides by the accumulation of secretory material in the centre of it. These open to the exterior through simple circular openings.

Pluricellular wax-secreting glands, composed of six cells and opening through a quinquilocular pore, occur in the stigmatic grooves.

Pluricellular glands with tubular ducts are distributed over the whole of the ventrum excepting the submarginal and the anal cleft area. This type of gland has a reservoir of secretion from which a number of ductules arise to form a main duct which leads to the exterior. The cell containing the reservoir is the largest of all of them. The gland is supported by eight or nine non-glandular cells of smaller size in its neck region. The changes affecting the structure of this type of gland in the life of the insect are also described.

Pluricellular glands, round in form, are distributed on the ventrum, excepting in the submarginal zone, the stigmatic grooves, the anal lobes and the anal cleft. The gland of this type is made up of more cells than the dorsal pluricellular type of gland. The duct leading to the exterior is a small cuticular tube implanted into the gland.

Distributed among the foregoing types of glands, but present more numerously in a part of the anal lobe, are the elongated pluricellular glands. This gland has a large central cell in the fundus region, and the duct is short, opening to the exterior by means of a single small pore. Some of these glands which occur in the posterior half of the body also take part in the production of the material for the construction of the ovisac.

Pluricellular club-shaped wax-glands occur in association with the anal ring opening through pores in it. The cells forming the gland are distinctly defined and a lumen is recognizable in them.

Unicellular setigerous glands of an attenuated shape, possessing narrow ducts leading to the base of the setae, occur on the dorsum and the ventrum.

38. On the origin and the development of the symbiotic organ or 'Mycetom' in the female of *Monophlebus quadricaudatus*, (Homoptera-Coccidae).

SUSARLA RAMMOHAN RAO, Benares.

1. The origin of the mycetom has been traced back in development to the so-called 'posterior granules' in the newly laid egg. The granules occupy a posterior position when the blastoderm is in course of formation.
2. Some of the cells of the blastoderm sink into the yolk and push the darkly staining granules before them. In this way some of the granules are engulfed by the secondary yolk cells to form the mycetoblasts.
3. The mycetom consists of a medullary chromophobic portion, a chromophilic cortical portion and an investing membrane. The medullary chromophobic portion of the mycetom, which stains feebly is formed from the vitellophagous cells, and the covering epithelial membrane which enshrouds the whole organ (mycetom) also owes its origin to the same.
4. The mycetom is at first subglobular being attached to the caudal end of the embryo in the anterior region of the egg.
5. After the revolution of the embryo, it divides into two halves, each moving to one side of the embryo.
6. Later on these rudiments elongate antero-posteriorly until they occupy a good deal of the body on either side of the alimentary canal.
7. It increases greatly in size from the first larval stage up to the adult. The function of this organ is probably nutritional, for it dwindles in size in a gravid and gestating female, and, finally, ends by being broken up into small bits.

39. The anatomy and the systematic position of *Hemimerus deceptus* Rehn., var. *ovatus*.

P. J. DEORAS, Bilaspur.

This work supplied the morphological details of *Hemimerus*, and tries to determine its systematic position, along with an attempt to

simplify the classification of *Dermaptera*. It describes the digestive, nervous, respiratory, and reproductive systems in detail. The most significant features are :—the primitive characters of the nervous system, and the spiracular openings, and also the presence of a double ejaculatory duct and the opening of the penis.

After a brief review of the affinities, the insect is shown to be close to the sub order *Forficulina*, and an attempt has been made to simplify the classification of the order *Dermaptera* as given by Burr (1915).

Medical Entomology

40. Distribution of *Anopheles sundaicus* Rodenw., by country boats.

P. SEN, Calcutta.

The paper deals with the transport of *Anopheles sundaicus* by means of country boats from its original breeding grounds in the coastal areas near Sundarbans to the environs of Calcutta. Boats coming up the different tidal rivers to the outskirts of the city were systematically examined during the period July 1933 to December 1934, and over four per cent of these crafts were sheltering the species in the cargo enclosed. The infected boats have invariably passed through the *Sundarbun* zone in the south or south-east of the delta. It is believed that the establishment of the species in the salt lake areas to the immediate east of Calcutta has been the outcome of repeated onslaughts of the species carried over into the area by country boats passing through Kristopur Canal which connects the river Ichhamati with the river Hooghly. Reference has also been made of the transport of the species by railway carriages into the important railway termini of the city. An excessive increase in the population of the species in Sundarban areas owing to the large-scale clearance of mangrove forests has probably set up the urge for an active dispersal of the species into the areas hitherto untrodden.

41. Experimental infection of mosquitoes with malaria in Calcutta city.

B. C. BASU, Mukteswar.

A total of 6,064 laboratory bred *Anopheles stephensi* were fed upon gametocyte-carriers (*Plasmodium falciparum*, *P. vivax* and *P. malariae*) and exposed in an air-conditioning cabinet to five different conditions of temperature and humidity corresponding to the spring, hot weather, monsoon, post-monsoon and cold weather conditions of Calcutta City, and the survivors were serially sectioned, stained and examined. The result indicates that in the case of *P. falciparum* the infection rates are lowest during the spring and the hot weather, moderate during the rains and highest in the post-monsoon months and cold weather. With *P. vivax* the infection rate is heavier in the monsoon and the post-monsoon periods than at any other season of the year. The highest infection rate with *P. malariae* is in the post-monsoon months.

Modern sanitation has very much reduced the amount of malaria within the city itself though the environs are still fairly malarious. In the days of Job Charnock, Calcutta suffered from pestilential malaria, and it was customary for the then small European population to hold an annual dinner at the close of the monsoon to celebrate their survival through another malaria season.

The work was conducted at the Calcutta School of Tropical Medicine with a grant from the Indian Research Fund Association.

42. Preliminary observations on the longevity of *Anopheles culicifacies* under controlled conditions of temperature and humidity.

RAJINDER PAL, Lahore.

In this paper some preliminary observations have been recorded on the longevity of *A. culicifacies*. Female adults hatched under laboratory conditions were subjected after a blood meal to controlled conditions of temperature and humidity.

At 40°C. (104°F.) females do not survive more than 24 hours when the humidity ranges from 60–100 per cent. The duration of life is comparatively enhanced when the temperature is lowered. At 65°F. mosquitoes could survive for 33 days. Further experiments are being conducted under various temperatures.

General

43. Insect associates of the Cashew plant (*Anacardium occidentale*) in South India.

T. V. RAMAKRISHNA AYYAR, Madras.

Though an exotic species the cashew nut plant has gained a strong foot-hold in this country, especially along the coastal and submountain areas of the Malabar coast from the Cape in the south to almost as far as Bombay. Nowadays, there is also a great demand for the nuts from outside countries and appreciable quantities of this commodity are being exported from the different ports of peninsular India. As a consequence thousands of acres of waste land which had been left uncultivated till recently have been planted up with this tree and year after year new areas are planted up. This is a tree which is found to grow fairly quickly in almost all kinds of soils, and in well-drained rain-fed hillsides it begins to bear well and give a good return in about six to eight years. Prospective planters of this crop will, however, do well, if in addition to the attention they pay to the various cultural aspects of the crop, to pay sufficient care and precaution to the healthy growth of the tree free from diseases and pests to which this crop is frequently subject. In this paper an attempt is made to give a brief account of the different insects associated with this plant, their bionomics as far as we know and a few suggestions towards their control.

44. Technique of estimating the population of the fruit fly, *Acanthiophilus helianthi* Rossi.

HEM SINGH PRUTHI, New Delhi.

In estimating the absolute female population of the fruit fly, *Acanthiophilus helianthi* Rossi, a serious pest of safflower at Delhi, the technique employed consisted in collecting fairly large numbers of female flies twice a week and liberating them after marking on the thorax with some oil paint and counting the recaptures in the collections of the females during each of the subsequent weeks. The weekly populations of the fly were then estimated from the ratio of flies captured and marked on the first date to that of marked and unmarked flies recaptured in each of the subsequent weeks.

The weekly populations calculated in the above manner indicated the density of the fly ranging between 20,000 and 7,69,230 individuals from second week of March to second week of April during which period the breeding of the fly was most intensive. After the second week of April a high rate of mortality, presumably due to the scarcity of the

host plant buds, resulted in a sharp decline in numbers of the fly, the population in the fourth week of April being 39,130.

Several factors influence the population of the pest, e.g., the high birth rate and rapid death rate, the Chalcidoid parasites, *Tropideucoila* sp., and *Ormyrus* sp., etc.

45. Lac demonstration campaign in the provinces of Bihar and Bengal.

M. P. MISRA, Ranchi.

The paper describes how the demonstration scheme was organized in the provinces of Bihar and Bengal in March 1935 by the Indian Lac Cess Committee.

Four demonstrators for Bihar were appointed in December 1935 and two for Bengal in September 1936. The demonstrators were trained by the Officer-in-charge both in the laboratory and the field in general entomology and in practical methods of lac cultivation on scientific lines. After a training of over a year and a half, the demonstrators were posted in September 1937 in different districts. The working of the first stage of scheme from September 1937 to August 1939 is described in detail, and the difficulties encountered in the demonstration work are enumerated.

On the basis of the experience gained, the scheme was revised by the Director of the Institute in February 1939, and was approved by the Lac Cess Committee and the Government of India. In September 1939 four more demonstrators were appointed for Bihar. The work of the Bihar demonstrators is being supervised by the Officer-in-charge Lac Demonstration Scheme, and that of the Bengal ones by the District Agricultural Officers of the Bengal Government. The supervision in the latter case is not as effective as in the first for reasons stated in the body of the paper.

In February 1939 necessity was felt to expand the scheme further. The chief feature of this expanded scheme are the free gifts of brood lac and pruning instruments to lac growers in selected areas in Bihar, the object being to gain the confidence of lac growers and to persuade them to adopt modified methods of lac cultivation advised by this Institute, which they hesitate to take up due to their conservative habits. This is being carried out with successful results in an area selected in the Ranchi District. Intensive lac demonstration schemes have been drawn up and circulated to various Provincial Governments interested in lac cultivation for opinion and co-operation.

46. A method of entomological section-cutting.

S. K. SEN, Mukteswar.

Sapre (1940) has described a new technique for cutting serial sections of chitinous objects. This involves the use of diaphanol as a 'softener' for the chitin and of dioxan as a dehydrating agent. Diaphanol, however, is liable to exercise a destructive effect on the internal tissues, while dioxan vapour is known to be toxic for the human subject (Lee, 1937; Carleton, 1938). In the present paper, a method is described whereby it is possible to obtain fairly satisfactory sections of chitinous objects without having to use any of the two reagents mentioned above. The method is briefly as follows: The specimen is fixed in Sherlock solution (Eltringham, 1930), dehydrated in 50 per cent alcohol and later in solvax (a proprietory substitute for dioxan). It is then dealt with by Peterfi's methyl benzoate celloidin method for double-embedding.

SECTION OF ANTHROPOLOGY

President:—TARAK CHANDRA DAS, M.A.

Somatology

1. Anthropometry and blood types of the Bangaja Kayasthas of Bengal.

R. N. BASU, Calcutta.

Bangaja Kayasthas of Bengal—their origin as depicted in the Vedas and the Puranas—the migration theories of the ethnologists are discussed—physical measurements of 100 adult subjects. Stature, Sitting height vertex, Relative sitting height, Head length, Head breadth, Cephalic index, Bizygomatic breadth, Facial height, Facial index, Cephalo-facial index, Nasal height, Nasal breadth and Nasal index, and the indices calculated therefrom. Observations on the following characters: Hair, Eye, Skin-colour. Determination of the Blood Groups and their distribution and comparison with other available data. Relation of Blood Types to Anthropometric data. Comparison with other racial types.

2. Anthropometric measurements of Śukla-Yajurvedīya Mādhyandina Brahmins.

(MRS.) IRAWATI KARVÉ, Poona.

(The Deccan College Post-graduate and Research Institute has undertaken the project of preparing a detailed anthropogeography for Maharashtra. For this purpose a survey of the sub-castes of Maharashtra is undertaken. This is the first survey in the above project. A student of the Institution is studying the community from the historical and ethnological point of view. In the meanwhile I undertook an anthropometrical investigation of the sub-caste.)

The Śukla-Yajurvedīya Brahmins form the majority of Brahmins in the Marāṭhī-speaking population. They are divided into strictly endogamous groups according to Śākhās. Of these the most numerous is the Mādhyandina Śākhā. The census reports have always grouped together all Deśastha Brahmins. Whatever the anthropological justification for this procedure, it is entirely wrong from the point of view of social customs.

I have measured in all about three hundred women (between twenty and forty-five) and about six hundred men (between twenty-five and fifty-five) belonging to this community. The samples were taken from nine different towns. A numerical presentation of the data will be made later as the calculations are being made now. I am giving below a brief summary of some of the salient physical peculiarities of the group. The people are of middle height possessing uniformly dark, sleek hair and brown eyes. Bluish green eyes and curly hair are extremely rare. They are broad-headed with very high forehead and the back of the head is flattened. The cheek-bones are sometimes prominent. I met with three or four rare cases of narrow eyes with the Mongolian fold. This latter peculiarity was pronounced in the case of children and very moderate in adults. The eyes are generally big and straight. The nose is also generally prominent and straight. In some cases the nose bridge was so high, that the usual slight depression between forehead and nose was

almost absent. The skin colour varied from the lightest of browns to very dark.

3. A further study of the somatometric and somatoscopic characters of the Santals

T. C. ROY-CHAUDHURY, Calcutta.

The present paper is based on the same fifteen absolute measurements and five indices as in my previous paper on the same tribe. This paper corroborates what I tentatively suggested elsewhere that the Santals are constituted of a short statured, dolichocephalic and chamaerrhine group (the Pre-Dravidian) and a medium statured, dolichocephalic and mesorrhine group (the Dravidian) to which might be added a third element with broad head and leptorrhine nose.

Anthropo-Biology

4. Race admixture on the Malabar Coast.

A. AIYAPPAN, Madras.

The history of the small islands of half-breed populations such as the Portuguese-Indians at Tangasseri and Anjengo in Travancore is described in this paper. The reaction of the parent communities to biological admixture is studied in its sociological setting.

5. On the finger and palmar print of the Indian juvenile criminals.

P. C. BISWAS, Calcutta.

This is a study of one hundred palm and finger prints of 50 delinquent boys of the Reformatory and Industrial School at Alipur in Calcutta.

As a result of my investigation of the finger and palmar prints of the above delinquent boys, it appears that there is no marked difference in the finger pattern of these delinquents and the normal individual.

It is very interesting that in the appearance of pattern loop on the Hypothenar, Thenar and the three Interdigital areas a considerable difference exists on the palm of the criminal and normal Indians. The pattern loop occurs in considerably lower number in the above areas of the criminal hand than that of the normal individual. In the Main-line and Axial-triradius there are no such differences.

Ethnic Psychology

6. Certain recent studies in racial intelligence.

N. N. SEN-GUPTA, Lucknow.

The paper gives a brief account of the attempts that have been made in recent years to estimate the level of intelligence of race-groups on the basis of intelligence tests and scholastic data. An attempt is made to analyse the facts and to bring out their psychological implications in regard to racial intelligence. The paper concludes that it is not possible to define I.Q.-values of specific racial groups.

7. Earlier and recent studies in racial character.

N. N. SEN-GUPTA, Lucknow.

The paper is a study of several psychological approaches to the study of racial character from the middle and end of the nineteenth century

to recent times. It attempts to estimate the value of these surveys of racial character in the light of the present outlook of psychology on this question. It concludes that there is no sound psychological foundation for racial characterology.

Prehistoric and Protohistoric Archaeology

8. Prehistoric culture in and about Bengal.

H. C. CHAKLADAR, Calcutta.

Besides sporadic find of artifacts in the plains and highlands of Bengal, a site abundantly rich in Palaeolithic implements has been discovered hardly six miles beyond the Bengal frontier, showing a crowded settlement of the men of the Old Stone Age; the numerous tools include both flake and core implements like those of the Soan Valley and the South respectively. No skeletal remains of Man have been found anywhere. Protomodern or Modern Man derived from the line Pithecanthropus-Wadjak-Solo, or from the Neanderthal-Cromagnon transition types of Tabun and Skuhl, as described by Keith, might have come to India from two directions.

Neolithic artifacts abound in the same region and some have been found in the plains. Shouldered celts found in Assam to the north-east, and Dumka-Singhbhum-Mayurbhanj in the south-west, of Bengal, show the passage through that country of Neolithic culture from Oceania-Malay-Burmah to Chota Nagpur, while pigmy flakes and beads show contact with the Indus Valley (Sukkur, Rohri, etc.) where the finest tools of Neolithic India have been discovered. Other items of the cluster of culture complexes marking the same period, such as pottery, agriculture, metallurgy, etc., might also have spread from the latter centre of diffusion. It is also not improbable that the outward expansion of Indic culture towards the Far Orient—Further India and the Pacific—as noted by Hutton (*Assam Origins in relation to Oceania*) and Handy (*Indian Cultural Influence in Oceania*) had commenced from Eastern India in the same Prehistoric Age.

9. The age of the boulder-conglomerate beds at Kuliana, Mayurbhanj.

NIRMAL KUMAR BOSE, Calcutta.

The geology of Kuliana is first described. Primary laterite is overlain here by secondary laterite containing numerous tools of palaeolithic type. In one locality within Kuliana, a boulder-conglomerate occurs in place of the primary laterite.

The course of the river Burhabalanga and its tributaries is then described in relation to the strike and the dip of the country rock; and it is suggested that the boulder bed is the work, not of the Burhabalanga itself, but of a tributary stream flowing into it from the neighbourhood of Tikaitpur.

Two more out-crops of similar compact ferruginous conglomerate are then referred to. One of them is perhaps post-Miocene as it overlies a calcareous clay of Miocene age. The question as to whether these are of the same age as the boulder-conglomerate of Upper Siwalik times, is discussed, and the opinion is expressed that the evidence in hand is too meagre for such correlation. Finally, the question of correlation by means of the stone implements themselves is discussed, and the conclusion is arrived at that, in the present state of our knowledge of the exact date of different types of tools, such an attempt would be premature.

10 Anthropomorphosis in the Indus Valley culture.

C. R. KRISHNAMACHARLU, Madras.

The paper touches upon the wide prevalence of anthropomorphic figures in ancient times in Europe, Egypt, Mesopotamia and India (Indus Valley) and draws attention to such figures occurring in the Mohenjo-Daro and Harappa relics. The association of some of these figures with the beginnings of Śiva cult in India and the possible connection of these with incidents in Śiva's life are suggested. That an important seal found at Mohenjo-Daro is very likely a composite representation of Patañjali and Vyāghrapāda, the devotees of Śiva, is inferred in the paper.

11. Anthropological significance of the *Āsā-daṇḍa*.

G. S. DUTT, Calcutta.

A careful comparison of the relics unearthed from the Mohenjo-daro, Harappa and other ancient India Valley sites, e.g. Jhukar, Amri, Channhudaro, etc., with the present-day Bengali folk arts and crafts reveal the fact that certain elements of the Indus Valley civilization of the Chalcolithic age appear to have continued in an uninterrupted succession right down to the present day in the Bengali region in the form of beliefs, practices, and traditional cult forms and art forms. One of these continuous traditional forms, and the most interesting and important of all, is the *Āsā-daṇḍa* or the metal disc standard used in Bengal nowadays as the standard of authority of the Gazi—the Tigers' God, as well as an architectural emblem on the pinnacles of various Siva and Vishnu temples. The striking resemblance of the unique form of this *Āsā-daṇḍa* with the standard of authority associated with the Urus Bull in the seals discovered among the relics of Indus Valley civilization at Mohenjo-daro and Harappa as well as the manner of their respective use strongly suggest that it is same cult form which has been handed down in an uninterrupted succession from the pre-Aryan culture of Indus Valley civilization to the folk culture of present-day Bengal and that the origin of the Vishnu-cult can be traced to the Chalcolithic age of India.

12. A preliminary note on neolithic typology of Chakradharpore.

D. SEN, Calcutta.

What seems to be a small but surprisingly rich neolithic factory site has been discovered in the Sanjai valley near Chakradharpore in the district of Singbhum. Huadreds of artefacts come from this small site which is to be shortly excavated. The geology of the site is now being studied and unless excavation is carried out, nothing can be said about any geological dating at the present stage of preliminary research.

Culturally, however, the industries seem to represent an early neolithic stage and typologically they offer interesting studies. The celt which is the common tool in the site shows a great variety of forms and features and represents nearly all the stages of its manufacture. The chipped celt is the most common. There also occur partially chipped and partially ground celts, partially chipped, partially polished celts, ground celts, partially ground and partially polished celts and finally polished celts—the last, however, are few. The amount of preliminary chipping left, in examples of partially chipped-partially ground or partially polished celts varies a great deal. An examination of the series of celts may reveal a course of typological evolution. Besides celts, characteristic chisels of great beauty and fine craftsmanship occur. Ringstones and other artefacts also come from this site. From the variety of forms it may seem that the celt people were bound to the

valley for a considerable time. How the chisels are genetically or otherwise related to the celt family is not yet known and the chisels themselves offer interesting typology.

Ethnography

13. The aboriginal tribes of Udaipur State.

M. B. BHADURI, Udaipur.

Udaipur is a state in the Eastern States Agency with its headquarters at Dharamjoygarh. The author, who is a state official, proposes in this paper to give an account of the aboriginal tribes living within the state. Fifteen such tribes live within the state—Kawar, Korwa, Kol, Kharia, Gond, Birhor, Bhuinhar, Majhwar, Dhanwar, Chero, Nagesia, Saonta, Sawara, Oraon and Pando which may be distributed amongst three linguistic groups—Indo-Aryan, Munda (or Austro-Asiatic) and Dravidian. The author discusses the geographical distribution of these tribes, and various other connected problems. He also discusses the question of the migration of these tribes in recent times within the Chattisgarh States.

14. The social customs and ceremonies of the Chik Baraiks.

ARUNCHANDRA GHOSH, Calcutta.

The writer in this paper has dealt with the social customs and ceremonies of the Chik Baraiks, a low weaving caste living in the north and north-western parts of Ranchi district.

He has investigated and personally observed the birth, marriage and death ceremonies of the caste.

A detailed description about them is given. He has also described how a child is named after the day of birth and also how a sister gets the feminine form of the name of her brother. Further detailed description of the outcasting ceremony and about the panchayat has also been given.

15. The eternal triangle in some Marathi folk-songs.

(MISS) BALUBAI SAPTARSHI *and* (MRS.) IRAWATI KARVÉ, Poona.

A number of Marathi folk-songs bearing on the relations between a brother, his wife and the sister have been collected in the Ahmednagar District. The folk-songs are translated into English and discussed in short in some cases.

Material Culture and Economic Life

16. Korku mundas.

K. P. CHATTOPADHYAY, Calcutta.

The Korku tomb posts known as mundas, and the ceremonial of their erection, referred to as sedoli rites, have been briefly described by Russell and Hiralal in their work on tribes and castes of the Central Provinces. The Gazetteer of the Amraoti District also furnishes certain details. The writer of this paper paid a visit in 1938 to eight Korku villages in the Melghat forest. Detailed accounts of the rites of disposal of the dead and of the erection of the mundas were obtained in four villages, and also from an educated Korku in Chikalda. The sedoli rites are shown to be comparable to the final bone disposal rites of the Santals and Oraons. Twenty-seven memorial posts were observed. Their types and certain details of carvings are also noted.

17. The Machis of Navsari.

S. T. MOSES, Baroda.

Introduction—Fishery Centres—Castes engaged in Fishing—The Kolis and early History—Evolution of new Subcastes and Castes—The 'Divine Origin' of fishermen: Bagawan's annoyance with a fish while bathing in the Narbada and consequent creation of a fisherman from His body—Machis and their sub-divisions: Koli Machis, Karda Machis, Dhimar or Dhebra Machis, Handia Machis and Girassia Machis. Handias were forced to catch fish for a Rishi who gave them protection when fleeing away from Parasurama. The Girassia Machis claim descent from a Mermaid. Kardas so called because law-abiding and paid all taxes (Kar) due—Occupations: Agriculture, Manual labour, Carpentry, Poultry-keeping, Vegetable selling, Jardoshi work and cottage making besides fishing including fishmongering and sailing—Fishing gear: nets (stake, cast, drift and drag nets)—Special fishing arrangements for Mullets and Mudskippers and a device used on the Tapti to entice and collect fish and prawns—Fishing Holidays—Fishing, etc., Ceremonies—Marriage Customs—Childbirth, naming ceremonies and names, etc.—Funeral Customs—Caste Assembly and Communal Administration—Religion, omens and exorcism—Habitations, sanitation and dress—Dietary and drink—Appearance—Measurements: Heights and Indices, Cranial and Nasal, of 30 subjects.

18. Division of labour in economic organization among the Rajbanshis or the Parois—a class of fishermen of Jessore, Bengal.

M. N. BASU, Calcutta.

The Rajbanshis or the Parois—a class of fishermen—live in a village named Sitarampur, in the sub-division of Narail in the district of Jessore, Bengal. The author of this paper had the privilege of carrying on field work in this village in May last. In this paper the author discusses the geographical position of the village, and records the results of census operations of the village carried out by him and gives the division of labour in their economic organization. These he had actually observed living with them in the same village.

19. The economic life of the Birjhia Asurs.

S. B. DASGUPTA, Calcutta.

The Birjhia Asurs are a section of the people generally known as Asurs living on the borders of Chota Nagpore and Palamau districts and Surguja State. They had been predominantly a '*Beonrā*' cultivating people, the same type of agriculture that is known as '*Jhuming*' in Assam area. A section of this people also smelts iron. But owing to extensive reservation of forest by the Government in the areas where they live, the Birjhias have been compelled to give up this type of cultivation. Iron-smelting requires charcoal which is made by burning trees. But as they cannot cut down trees according to their needs because of the Government restriction, this occupation also is faced with great difficulties. Moreover, the indigenous iron cannot compete with the price and quality of the imported iron. Hence this occupation may also be totally given up in time. The people at present are fastly adopting plough cultivation. But as the Birjhias have made the hills and forest their home so long, they are at great difficulty in finding out ploughable and productive lands. In spite of hard labour and frugal habits they cannot make both ends meet at all times during the year. Hunting and collection of edible roots, tubers, flowers and leaves also constitute other important economic

pursuits next to agriculture. At times when such collected crops as *Mahuā* flowers fail they are faced with utter starvation. Exodus to tea gardens takes place during this time. In recent years the demands from tea gardens are also not encouraging. Under the circumstances unless they can get better cultivable fields or unless they are utilized in some other occupation, this already dying people may be altogether extinct in no distant future.

20. The Khasi huts of Mawphlang.

RAM KRISHNA MUKHERJEE *and* RAM CHANDRA BASU, Calcutta.

The structure of the Khasi huts of Mawphlang was studied by the writers under the guidance of Prof. K. P. Chattopadhyay. Gurdon in his work on the Khasis of Assam has described the old Khasi hut as elliptical in shape, but in Mawphlang village it was found that the huts can be more strictly said to be 'U'-shaped, the bend of the 'U' being the front, the two parallel arms the sides, and a straight line connecting the two ends of the arms the rear. The old houses had walls made of bamboo and wood, or stone and wood, and a thatched roof. The house types are now changing both in structure and material.

From a study of all the huts of the village it was found that out of 160 huts, inhabited at present, the typical 'U' type of huts form about 11·3%; the flattened 'U' type about 35·%; the intermediate type, which has totally given up the 'U'-shaped ground plan but has its interior of the old type, about 27·5%; and the English bungalow type about 26·3%. This data show how rapidly the old type of Khasi house is now changing.

21. Tattooing among the Oraons of Marwai, District Ranchi.

TARUN CHANDRA BAGCHI, Calcutta.

The writer in this paper has described the actual process of tattooing adopted by the Oraons of Marwai, District Ranchi. He personally observed how an young Oraon girl of thirteen was tattooed by a Nagesia Kisan woman of the locality. The process along with the materials and instruments are described. Sketches of designs executed on the different parts of the body are also given.

22. Cleaning, preservation and repairing of glass objects in Museum.

M. N. BASU, Calcutta.

Chemical composition—Processes of cleaning, preservation and repairing of glass are discussed in this paper. Sweating of glass and diseased condition of glass, and the methods of cleaning and preservation under this condition are also dealt with.

Society

23. Kinship system and kinship usages in Mahārāṣṭra.

(MRS.) IRAWATI KARVÉ, Poona.

Mārāṭhā kinship terminology is very rich and varied as it uses the concepts and terms of Sanskritic as well as Dravidian origin. It has terms for four ascendant generations and four descendant generations in the direct male line, the fourth term suggesting the severance of kinship. Among collaterals the concept of cousinship is absent as in all Indian kinship systems. The parallel cousins are called Geschwister and the cross cousins 'Mehuṇe', i.e. marriage mates. Among descendants, there

are sons and daughters. In this category are reckoned, besides own children, those of the brother (man speaking) and those of the sister (woman speaking). The non-sons and non-daughters are the children of the sister (man speaking) and the brother (woman speaking). The words for sister's husband and wife's brother are the same; similarly, those for husband's sister and brother's wife are also the same. There are many pairs of relations having the same term. The principle of reciprocity and difference of terms used according to the juniority or seniority of the speaker are also found.

Some very interesting conclusions can be drawn from the conformity or otherwise of different castes to this kinship pattern. This pattern is not the symbol so much of moiety and clan organization as of families which have been practising in-breeding for generations. The Mārāṭhā kinship pattern belongs to the southern pattern and yet in some important features it is quite distinct.

24. Khasi kinship and social organization.

K. P. CHATTOPADHYAY, Calcutta.

In a paper on Khasi marriage rules Prof. Hodson has tried to explain the special features of the Khasi kinship terms and marriage rules on the hypothesis of a former dual division of Khasi society, and certain new social forces which came into operation when the dual society broke up.

Hodson used for his work, the kinship terms noted in the Assam Census Report, Gurdon's work on Khasis and a dictionary by U. Nissorsing. A full list of Khasi kinship terms was published by Rai Bahadur S. C. Roy shortly afterwards. The writer of this note collected certain additional details regarding Khasi social rules in a recent tour in Khasi Hills, and collected kinship terms afresh, on the genealogical method, to check the list published by Rai Bahadur S. C. Roy.

Khasi kinship terms show that the father's brothers, the mother's sister's husband and the father are referred to by the same term, along with certain qualifying words denoting seniority and juniority. A similar grouping is found in the case of the mother, the mother's sisters and the wives of the father's brothers. These and similar other features of Khasi society are ascribed by Hodson to a previous dual basis of Khasi society. The present writer shows that these features are all explained by the fact that the fundamental social unit among Khasis is the family house and the extended family associated with it; the kur represents a later stage in its expansion. Marriage sets up new relations, but does not disturb this basic structure of Khasi society.

The kinship groupings are worked out in detail and shown to have been influenced by (a) residence, (b) inheritance, and (c) succession to rank as well as authority. Marriage rules have also had their share of influence on the terminology, but they have played a less important part, than the other factors taken together.

25. The Garo Law of Inheritance.

J. K. BOSE, Calcutta.

According to the Garo Law of Inheritance after the death of a woman the property goes to the privileged daughter known as *nokna*. In the absence of a daughter, a woman can adopt a daughter of her sisters or a girl from her machong to become her *nokna*. In the case of a childless woman who has not adopted any girl, her property will be equally shared by her sisters who are married in the father's machong. In the absence of all these the property is inherited by the nearest woman relation of her machong.

26. Incest and its control among the Kurichiyans of Wynad.

A. AIYAPPAN, Madras.

The incidence of incest is relatively high among the Kurichiyans who are otherwise an extremely well-ordered group. In this paper the operation of social and religious sanctions against incest and their failure due to the safety-valve provided by Christian missions are described, with illustrative data collected by the writer during the course of his field work.

27. The Indian cowherd god.

NANIMADHAB CHAUDHURI, Calcutta.

A re-examination of the position of Gopāla-Kṛṣṇa or the Indian cowherd god, in the light of certain facts which have not received adequate consideration, shows that the view that he was an independent deity of Christian origin brought from outside India by the Abhiras or that he was the same as Vāsudeva-Kṛṣṇa, the pastoral associations being borrowed from an older tradition and developed by the Abhiras, is untenable. The doubt suggested about the identity of epic Kṛṣṇa and cowherd Kṛṣṇa by the 'incongruity' in their traditional history of Kṛṣṇa is confirmed by the almost complete silence in the epic about cowherd Kṛṣṇa and by the mention of the hostility of the Abhiras to the house of Kṛṣṇa-Vāsudeva in the episode of the kidnapping of many of the Vṛṣṇi ladies when they were being escorted by Arjuna from Dvārakā to Indraprastha. The inference drawn from these facts is that cowherd Kṛṣṇa was an independent deity of Abhira origin.

Then there is the story in nearly all the Vishnuite Puranas of cow-herd Kṛṣṇa's opposition to the celebration of Indra's festival with graphic accounts in the Viṣṇu Purana, Harivaṃśaṃ, etc., of the propagation by him of a primitive type of nature and animal worship among the Gopas, the assertion made by him that this religion was in accordance with their life of forest-dwellers and the threat of violence held out to them in case of refusal to return to this religion, which show him in the rôle of the tribal chief of the Abhiras who resented the increasing influence of Brahmanism on his people and stoutly defended the old tribal religion. The inference drawn from the above is that Gopāla-Kṛṣṇa was a tribal hero of the Abhiras.

After his deification and absorption into the Hindu pantheon Gopāla-Kṛṣṇa, in his two aspects of child-god and lover-god, has come to oust epic Kṛṣṇa and Viṣṇu in some measure, from actual worship among people, as many of the Vaiṣṇava festivals show.

28. Some cure deities.

NANIMADHAB CHAUDHURI, Calcutta.

Beliefs in divine agency and magical agency of cure have prevailed side by side from the earliest times, and scientific progress has not banished these beliefs. The divine agency operates directly when deities with healing powers are invoked to intervene personally, or indirectly, through secondary divine agencies, that is, objects which derive their potency from divinity through intimate association or transmission. The paper deals with a number of instances of direct appeal to deities for cure purposes among Hindus, Hinduised tribes and tribal peoples.

Examination of instances selected from all parts of India show: (1) that three classes of deities are worshipped for cure, namely, old Brahmanical deities, e.g. Rudra-Śiva and the Devī in the form of Kālī, local deities affiliated to them, e.g. Ulai-Caṇḍī, Biranath, etc., and purely folk deities, e.g. Ghentu, Vasana-Varī, etc.; (2) that throughout India

female deities are worshipped in epidemic outbreaks of cholera and small-pox; (3) that in case of other diseases too, female cure deities predominate both in number and importance over male cure deities; (4) and that there is general tendency among all classes of devotees to affiliate different classes of female cure deities to the Devī or her Puranik demoniacal form Kālī.

This examination further shows that there are two contradictory elements in the conception of female cure deities identified with Kālī, an element of fear based on their destructive power and an element of faith based on their beneficent power. This dual aspect may be traced to the old Vedic conception of Rudra who is the giver as well as the curer of disease.

SECTION OF MEDICAL AND VETERINARY RESEARCH

President:—A. C. Ukil, M.B., M.S.P.E., F.S.M.F.B., F.N.I.

A. MEDICAL RESEARCH

Medicine and Public Health

1. Weil's disease in Calcutta.

M. N. De, Calcutta.

This disease is becoming increasingly common in Calcutta. During the last three years the writer had under his care 18 cases, 3 in 1938, 5 in 1939 and 10 up till now in 1940. Most of the cases come from the old congested and unhygienic parts of the city. The disease is usually ushered in with acute onset of high fever, chill and rigor and severe agonizing pain in the head, body and legs. Some get nausea and vomiting and their eyes become acutely congested. The fever usually lasts for three to four days, sometimes a week. The most characteristic feature is the appearance of varying degrees of jaundice after the temperature drops to normal. Leucocytosis with high polynucleosis and evidences of damage to the liver and kidneys are very constant findings. In severely infected cases blood urea and N.P.N. may be very high and the signs and symptoms of renal failure are very acute. Death takes place from uraemia in the second week. In favourable cases which recover prostration is very marked and prolonged and the jaundice may persist for months. Bacteriological confirmations of the cases under review were made by Professor B. M. Das Gupta of the School of Tropical Medicine, Calcutta.

2. Seasonal variation in the incidence of filarial lymphangitis.

S. Sundar Rao *and* P. V. Sukhatme, Calcutta.

Statistical analysis of the variation in monthly admissions of patients, new and old, at the filariasis clinic of the Calcutta School of Tropical Medicine, during the period from 1929–38 is carried out with the object of defining precisely the nature of the periodical movement recurring year after year in the incidence of filarial lymphangitis. The analysis of 11,108 cases shows that the monthly incidence during the monsoon period from July to September when the humidity is high and the temperature is optimum, is 40% higher than in the winter period from October to February. The period from March to June shows an incidence slightly higher than the average giving an appearance of a prelude to the monsoon period of the highest incidence.

3. Further observations on tuberculosis in relation to industry.

A. C. Ukil, P. K. Sen, *and* M. Bose, Calcutta.

(*Tuberculosis Enquiry, Indian Research Fund Association.*)

A serial survey of all the available workers of a jute mill was undertaken and finished. 4,816 workers were physically examined and

tuberculin tested. Complete industrial and previous histories were collected. Those workers showing suspicious signs or symptoms or high tuberculin reactions were X-rayed.

82·4% of the workers were tuberculin positive showing a very high infection rate.

Among those earmarked for X-ray: 102 clinically suspected, 32 with bronchitis and 639 strong and moderately strong tuberculin reactors have been radiologically examined.

Of the 773 workers X-rayed, 70 or 9·05% showed 'definite' and 43 or 5·6% showed 'probable' evidences of active tuberculosis: the total being 14·65%.

4. A neuro-abdominal syndrome—a new complex of symptoms connected with chronic mucous colitis.

H. M. SELZER, Lahore.

The author describes a new syndrome in Indian male patients of all ages and races, consisting of a typical mucous colitis, cholecystitis and a spinal muscular atrophy of the type Aran-Duchenne. Some of the patients show a relative lymphocytosis, all present a slight damage of the liver-tissue (Takata-Ara-Test positive). All other laboratory examinations are negative. The author does not bring forward any definite explanation of this syndrome, but ventures the hypothesis that toxins eliminated from the colon are brought via the blood vessels to the liver, concentrated in and so damaging the gall-bladder and then fixing mainly in the anterior horn cells of the cervical segments, which are phylogenetically the better differentiated and youngest ones of the spinal cord, and sometimes even attacking certain bulbar centres. Another hypothesis could be that the toxins are produced primarily in the liver cells. Further work by a greater number of clinical workers with more materials is needed to clear this syndrome, which might bring us the final contribution to the knowledge of the pathogenetic factors underlying the three pathological entities representing this neuro-abdominal syndrome.

5. Hysteria—a clinical study of 160 cases.

NAGENDRA NATH DE, Calcutta.

The material for study was from the Psychological Out-patients' Dept. of the Carmichael Medical College Hospitals run by the Indian Association for Mental Hygiene during 1933–1940. Of 1,177 total mental cases, 160 or 13·6% were hysteria. Males were more than double of females. Age incidence varies in different sexes and in different countries. Childlessness predisposes to the disease in both sexes. Heredity plays an important but indirect rôle. Precipitating factors are important in cases of anxiety hysteria but not so much in conversion hysteria. Proportion of these two types was 101 : 58.

Symptoms differ somewhat from text-book patterns in quality and in frequency. Closer relations with schizophrenia and paranoia are observed than are usually thought.

6. Incidence of lead poisoning among Hindu women.

K. N. BAGCHI, Calcutta.

Cases of lead poisoning are occasionally noticed among the solderers and printing press and type foundry employees in this country. So far very few cases of lead poisoning have been recorded among women on account of the fact that there are no women employees in the printing

press, type foundries and other industries in which people are exposed to lead.

In connection with an investigation on lead in human tissues it was discovered that hair of Bengalee married Hindu women is very rich in lead—as much as 508 mg. of lead per kilo could be detected in hair (Bagchi *et al.* 1939). The source of lead was traced to cheaper qualities of vermilion containing red lead used by married women.

Mild forms of lead intoxication showing signs and symptoms of gastro-intestinal disorders are usually diagnosed as dyspepsia. In some cases the early signs are lassitude, sleepiness and a general disinclination for effort without any of the usual signs of plumbism (Monier-Williams, 1938), and they are overlooked or ascribed to more common ailments. In certain cases anomalous nervous symptoms develop which are not accounted for. These signs and symptoms may remain dormant and unsuspected until stirred up into activity by starvation, medication, acute infections or an alteration in metabolic process. Cases of sterility and frequent miscarriages in women are always ascribed to specific infection or displacement of the uterus even when they are not confirmed by actual examination or blood tests. Lately many such cases are ascribed to vitamin E deficiency but the possibility of plumbism is never thought of.

In women giving large quantities of lead in their hair (Bagchi *et al.*, *Ind. Jour. Med. Res.*, 1940), the faeces and urine gave also high lead figures—about 10 times the normal. This finding indicates that absorption of lead takes place through the scalp where vermilion is applied to the hair-parting. Daily absorption of lead in minute doses produces a mild insidious type of poisoning which differs widely from the classical type with the text-book symptoms (*Porritt. Brit. Med. Journ.*, 1931).

It is believed that women are more susceptible to the action of lead although this view is not shared by the German writers. All, however, agree that in women lead poisoning assumes a more severe form than in men. Menstrual troubles are very frequent both in insidious and classical types of lead poisoning (Occupation and Health. Published by the International Labour Office of the League of Nations, Geneva, 1934). Mother, suffering from lead poisoning, transmits lead to her suckling baby through the milk and a slow poisoning in the child may be set up (*loc. cit.*).

The medical profession in India should take note of these facts and remember the possibility of plumbism when dealing with cases of dyspepsia, nervous disorders, avitaminosis, menstrual troubles, abortions, etc.

Even in classical type of plumbism, punctate basophilia are seldom found in this country. Blue line on the gums is frequently associated with pyorrhoea and gingivitis especially in dark people and hence one should not depend on these signs in diagnosing lead poisoning. Careful determination of lead in the faeces by the latest semi-micro methods of analysis, may indicate the actual state of things. The physician should remember that lead absorption does not always mean lead intoxication. 'The mistakes in the diagnosis of lead poisoning are often due to not expecting it.'

7. Comfort in class rooms and laboratories.

D. V. Subba Reddy, Vizagapatam.

On 20-3-1940, all the fans in a big room in the Medical College stopped suddenly while the students were answering examination papers. The day was not hot, the dry bulb temperature inside the hall being only 86°F. and wet bulb 78°F. As soon as the fans stopped, the students began to complain of increasing discomfort and stuffiness in the room. Within fifteen minutes, the complaints became less numerous and less frequent. Those who were unable to proceed with the work

recommenced answering papers. After another 15 minutes, the fans began to work. The relief was evident in the faces and in the increased effort and output.

In the course of the next hour, the same cycle of events repeated itself. Kata-thermometer was available only when the fans recommenced to work after the second interval. Readings were taken at different parts of the hall and the subjective sensations of the students were correlated to the Kata-readings.

Two points were brought out by the observations:—

1. It is not so much the alteration in the environment of the room as the abruptness of the change that determines the degree of the subjective symptoms and feeling of stuffiness.
2. A dry Kata cooling power of 3·55 (noted under the fan when the fans were working) seemed to afford a satisfactory degree of comfort, though the environmental temperature was 86°F. This was probably due to the sudden increase in the movement of the air following a period of stagnation of air.

8. Bodily sensations and sudden changes in environmental temperature.

D. V. SUBBA REDDY, Vizagapatam.

A dry bulb temperature of about 100°F. and hot winds are not usual at Vizagapatam in April. On 1-4-1940, from about 9 A.M. hot winds began to blow from a westerly direction (from landward). In the evening, the temperature was still high, though the hot winds abated. Meteorological report for the day gave the maximum as 97°F. The temperature was higher on the western slope of the town which bore the brunt of the hot winds, while the Observatory recorded only their effect on the air beyond the fringe of hot winds.

The inhabitants and workers experienced a moderate degree of discomfort, lassitude and even prostration particularly those who were exposed to hot winds. If the temperature of the air had risen gradually or in stages, effecting the same rise in a few days instead of by an abrupt elevation, the identical environment would not have produced the same degree of discomfort and severity of symptoms.

Apart from the abruptness of the change, it is also probable that the permanent residents of Vizag who have acquired a certain degree of equilibrium with the equable climate of Vizag also have a partial inability to rapidly adjust themselves to wide variations in temperature. It is suggested that the rate of change of the environmental temperature and the previous thermo-regulatory adaptations determine the capacity of individuals to withstand a rise of 10°F. or more, in the environmental temperature.

9. Further notes on the distribution of the freshwater fishes of Dharwar and surrounding districts.

P. W. GIDEON, Dharwar.

This paper is a cotinuation of the work communicated to the Twenty-fourth Session of the Indian Science Congress and later published in the records of the Malaria Survey of India.

A few more genera and species have been added including a number from Portuguese India.

10. Experiments in the control of guineaworm infection in step-wells by means of larvivorous fish, *Rasbora daniconius*, and chlorogen.

P. W. GIDEON, Dharwar.

While experiments in the control of guineaworm have been conducted in many parts of India, by various larvivorous fish singly or in combination with others, this paper is concerned with the control of guineaworm by means of one fish, *Rasbora daniconius*, which is found in large numbers in almost all local tanks.

Observations on the value of chlorogen as an aid to fish control is also mentioned.

11. Coronary occlusion without thrombosis and its prophylaxis.

J. N. MAITRA, Calcutta.

Cases of sudden death occur in Bengal as in other parts of the world. Persons in apparently good health with complaints of minor ailments die suddenly and on post-mortem examination a big heart with coronary arteries occluded has been the finding. Careful examination of these cases with the aid of modern scientific methods may reveal the actual condition. We can early diagnose these cases and increase their longevity.

On the autopsy table, cases of sudden death suspected to be of medico-legal origin revealed invariably an enlargement of the heart. The hypertrophy was so great that the weight reached 20 ounces (normal 5 to 7 oz.) with coronary arteries occluded. Far advanced cases with chronic and sub-acute pain of varying duration (months and years) have been known to have died on the examination table.

Attention of the profession has been drawn to conditions necessitating thorough investigation of the cardio-vascular system. Progressive occlusion of coronary arteries may easily be managed by suitable treatment with breathing exercise (like Pranayam) after excluding the extracardiac affections.

In apparently healthy persons of good physique with vague pain and sub-acute discomfort in the chest, the condition of coronary arteries should be recognized and sudden death may be averted.

12. Radiological appearances of osteoarticular lesions in leprosy studied through radiology.

MARIO SOARES DA VEIGA, Nova-Gôa.

The author having taken at Macasana Leprosarium of Portuguese India, roentgenograms of the hands and feet, of hundred in-patients with several clinical forms and at different stages of evolution, the classification of which he gives, arrives to the following general conclusions:—

Osteoarticular lesions were seen in 98 per cent of the cases.

The lesions are characterized by:—

(*a*) Their appearance in the extremities of the hands and feet.

(*b*) The pathological process is essentially destructive and characterized by osteoporosis, rarefaction.

(*c*) This change is found under three fundamental types: Localized osteoporosis, leprous osteitis and widespread destructions leading to mutilations. Practically several combinations of those main types are found.

(*d*) The localized destruction of somewhat roundish type, the single and multiple cysts of Jungling's type and the forms—these are more rare—of Schurer-Waldhien's type were found generally in cases with cutaneous involvement and slight changes of nervous system.

(e) The widespread osteoarticular destructions leading to mutilations are seen in advanced cases.

(f) As regards the genesis of these osteoarticular changes, the author combining radiological signs with the clinical findings states:—

1. The rarefying osteoporosis is the result of localized infection developed through the vessels.
2. The osteoarticular changes of neurodistrophic type are the result of the specific involvement of the nervous system and are revealed by destruction of the bones, multiple osteoporosis and mutilations, sometimes symmetricals.

(g) The intensity of the destructive process in the feet does not appear to be due to merely mechanical causes but rather to specific selectivity of the pathologic process.

(h) The quantity and extension of the osteoarticular lesions increase in proportion to the age of the disease, being also, more frequent in the nervous forms.

The author makes differential diagnosis of the leprous radiological lesions from the lesions found in Raynaud's disease, tuberculous osteitis, syphilis, cocidiosis, sclerodactylia, sclerodermia, Bosnier-Boek's disease, lupus perniccus, syringomyelia, tabes and certain forms of osteolyse.

Pathology, Microbiology and Parasitology

13. Weil's disease.

A. K. SEN *and* A. K. HAZRA, Calcutta.

1. Historical—
   (a) Clinical Symptom Complex. (b) Identification of the causative micro-organism—its position in bacterial world. (c) In India—(i) Clinical. (ii) Isolation of the causative organism.
2. Bacteriological study—
   (a) Media and culture. (b) Peculiarities.
3. Selection of 'Strains' for purposes of production of specific anti-sera.
4. Anti-sera—
   (a) Historical. (b) Special reference to our anti-sera.
5. Standardization.
6. Clinical use—
   (a) Curative. (b) Prophylactic.
7. Short survey of methods of diagnosis of Weil's disease—
   (a) Cultural. (b) Serological. (c) Experimental. (d) Difficulties of early diagnosis.
8. Conclusion—
   (a) General. (b) Clinical Survey. (c) Epidemiological. (d) Vaccine prophylaxis.

14. A simple serological test for hepatic cirrhosis.

M. NARAYANA PAI, Guindy (Madras).

This test, known as the Takata-Ara Reaction, has been done on 51 cases of hepatic cirrhosis in South India. It was found positive in 47 cases and negative in 4. In other cases of hepatic insufficiency, such as

acute yellow atrophy, chronic venous congestion of the liver and infantile biliary cirrhosis, the test was positive. In a series of 55 control cases it was found uniformly negative except when hepatic insufficiency was co-existent.

15. The rôle of chronic dysentery in the etiology of portal cirrhosis in South India.

M. NARAYANA PAI, Guindy (Madras).

One hundred and ninety-four cases of portal cirrhosis were investigated in the Raja Mirasdar Hospital, Tanjore, during three years, 1935 to 1937. Sixty-four of these cases gave a definite history of dysentery prior to onset of ascites. Eleven cases denied a history of dysentery. In the remaining 119 cases, there was no definite record of the presence or absence of a history of dysentery in the clinical notes.

Forty-three cases of portal cirrhosis, from various hospitals in the city of Madras and in the mofussil, were serologically examined for agglutination against B. Flexner and B. Shiga. Blood sera or ascitic fluids of 21 cases agglutinated B. Flexner in a titre of 1 in 25 to 1 in 200. Sera of 8 cases agglutinated B. Shiga in a titre of 1 in 25 to 1 in 200. Sera of 21 cases did not agglutinate either organism.

In a series of 22 control cases, the serum of only one case agglutinated B. Flexner in a titre of 1 in 50. Sera of the other 21 cases did not agglutinate either B. Flexner or B. Shiga.

16. Pulmonary oedema in cholera.

D. N. BANERJEE, Calcutta.

Pulmonary oedema is one of the most dangerous and frequent complications of cholera, being responsible for a large number of deaths. In spite of gross renal failure in cholera no oedema in any part of the body ever takes place either during the course of the disease or during convalescence. Oedema of the lung is the only exception and that invariably takes place during the active stage of the disease. It is generally associated with vasomotor failure. In a series of 25 cases of cholera showing oedema of lungs clinically, 22 cases showed marked involvement of the air spaces being filled up with eosinophilic homogeneous albuminoid material containing few cells. Red blood cells are the only types of cells found. All the blood vessels, especially the alveolar capillaries, are greatly engorged. The pathogenesis of this condition is discussed in which particular stress has been given on the condition of shock, vasomotor failure and increased permeability of the vessels. A note of warning is given regarding the treatment of this condition particularly in the use of adrenalin, hypertonic glucose and calcium chloride.

17. Mechanism of renal failure in cholera.

D. N. BANERJEE, Calcutta.

Renal failure and the vasomotor failure are the two most important problems in cholera. In fact, these are the chief causes of death in the cholera hospital in the present day as no case is allowed to die of loss of fluid. Oliguria from the beginning progressing to anuria with progressive increase in urea, N.P.N. and other metabolites in the blood ultimately leading to death from symptoms of uraemia forms the usual picture. It has been repeatedly shown by us that the structural changes in the glomerulus and the tubules are characteristically insignificant while the renal vascular changes contribute by themselves a great abnormality in the renal function. The capillary reaction in the kidney forms a part of the general vascular reaction of the whole body.

The mechanism of renal failure in cholera is shown to be in the form of a vicious cycle with cholera toxin leading to increased permeability of the capillaries—atony of the capillaries—loss of fluid resulting in haemoconcentration and hypochloraemia—reduced effective blood volume resulting in capillary stasis, fall of blood pressure, retention of metabolites—tissue anoxia—atony of the capillaries starting the vicious cycle anew.

The renal failure in cholera is thus extrarenal in nature.

18. The scope and need for paleopathology in India.

D. V. S. REDDY, Vizagapatam.

Paleopathology is the term introduced by Ruffer to describe ancient evidences of disease. The range of geological and prehistoric periods for which our only means of understanding the types of diseases of those times is paleopathology.

Materials and methods of study. Cultural and practical uses of the study.

Knowledge and co-operation of a variety of professions and experts required. The geologist, the paleontologist, the anthropologist, the archaeologist and the medical man have all their different rôles to play.

Review of the important studies on the injuries and diseases of 'fossil men'. Surgery of the paleolithic and neolithic races. Data collected by the study of the human remains of the ancient civilizations particularly those from Egypt. A list of diseases of ancient Egyptians. No convincing proof of the existence of syphilis, tuberculosis and rickets. Surgery among ancient Egyptians. Diseases of ancient Iranians. Researches on the diseases of ancient Peruvians and of the pre-Columbian North American Indians. Trephining was a common surgical procedure among ancient Peruvians. Evidences from skull bones indicate the existence of syphilis in pre-Columbian America.

Indian civilization, as revealed in recent excavations, stretches back to third or fourth millennium B.C. and is coeval with, if not anterior to, the Egyptian and the Sumerian civilizations. Our only sources for the study of history of medicine in prehistoric India have been the Vedas about whose date of composition there is wide divergence of opinion. The ever-increasing number of archaeological finds from various localities. in India require to be studied more carefully. They may throw new light on the injuries and diseases as well as the beliefs and practices of the inhabitants of the Indus valley and other ancient sites.

A tabular statement showing the site of discovery, the date of the material according to archaeologists and the number and nature of skeletal remains. Photographs and brief descriptions. The available data or reports on the evidences indicating injuries and diseases in the disposition, gross appearance and in the skeletal finds are very scattered and scanty. No attempts seem to have been made to have the human remains examined microscopically, chemically or radiologically. It is hoped that the archaeological department will soon make arrangements to give full facilities for the examination of the rare and valuable finds preserved in the various museums in India.

19. Some anomalies of Widal reaction and the value of different laboratory investigations in the diagnosis of enteric fevers.

PURNENDU KUMAR CHATTERJEE, Calcutta.

In a large percentage of cases treated at the Calcutta Medical College Hospitals, the Widal reaction was negative even on repeated examinations. Diagnosis in these cases was confirmed by positive blood or stool cultures in some cases, in others only on clinical grounds.

In another larger group of cases agglutination to H antigen was only positive, that to O remaining negative even on repeated examinations. Diagnosis in these were confirmed by positive blood or stool cultures or rising titre of H agglutination and in others on clinical grounds. Similarly in another small group O agglutination was only positive, that to H remaining negative. In most of these cases blood cultures were positive.

Amongst other anomalies: in one group there was a progressive diminution of titre in cases in which diagnosis was confirmed by positive blood or stool culture. In a smaller group agglutination to H or O or both antigens of one bacillus was positive, blood culture showing another bacillus.

Incidence of positive results of blood, stool and urine culture at different periods of the disease is tabulated and their value in diagnosis discussed.

Changes in total and differential counts of W.B.C. are tabulated and discussed. The paper gives an analysis of about 500 cases.

20. Chemical studies on the Aronson culture medium for cholera organisms.

E. K. NARAYANAN, Calcutta.

Among the culture media that are being used in bacteriological work there are some which await a chemical explanation of the part played by their ingredients. An example is the Aronson medium in which sodium sulphite and basic fuchsin are ingredients whose functions do not seem to have been elucidated. Being faced with the problem of improving this medium with respect to these ingredients, a preliminary knowledge of the rôle of these substances was found to be necessary and results so far obtained show that the production of red cholera colonies on this medium is due to acetaldehyde which is an intermediary in the carbohydrate metabolism of this organism. The function of the sulphite appears therefore to be two-fold, viz.

(*a*) to reduce the dye to its colourless leucobase during the making of the medium, and

(*b*) to act as a fixative for the aldehyde produced by the organism when it is cultured.

The accumulating aldehyde which is most abundant nearest the colonies acts on the colourless leucobase of the dye giving the characteristic red colouration. The dye in this case does not seem to be a stimulant for the bacteria as certain other dyes are supposed to be in particular cases.

A certain optimum proportion of the sulphite should be introduced into the medium as, for one thing sulphite inhibits the growth of the organisms, and secondly, in large quantities, it inhibits the reproduction of the red dye by the aldehyde.

Although it is generally believed that acetaldehyde is a common intermediary in the carbohydrate metabolism of all organisms, no direct proof appears to have been obtained for the pathogenic bacteria. Moreover, in the culture medium of Endo, a counterpart of the Aronson, certain pathogens appear coloured red and others colourless. Therefore, it would seem as though aldehyde production need not be the common intermediary for all bacteria. Work on these lines is in progress.

Based on the aldehyde view, an explanation of the use of the sodium sulphite in the Wilson Blair medium for cholera also suggests itself. Sodium sulphite combines with the aldehyde, its conversion into acid is retarded and as a result the *p*H of the medium as a whole remains more or less stationary. The maintenance of an alkaline *p*H, it is well known, is the basis of the differential isolation of cholera from a mixed faecal culture.

21. Standardization of gradacol membranes.

E. K. NARAYANAN, Calcutta.

The average pore diameter (a.p.d.) of a gradacol membrane is determined with the help of the viscosity equation of Peuselli by making observations of the rate of flow of water, the water content and the thickness of the membrane in question. While determining the rate of flow of water for membranes according to the simplified device (Bauer and Hughes, *Am. J. Physiol.*, Vol. 18, 934-35) of a burette connected to a cell of two well-ground bottle necks pressed into contact with the membrane in between, it was found that the time taken for the same volume of water to fall from the zero level of the burette, every time in successive experiments, was not constant but went on increasing as the number of times the experiment was repeated. The water was free from all particles removable by ordinary filter paper and still this discrepancy was met with; however, by filtering the water through a membrane of the same porosity as that under study concordant results were obtained. This essential precaution in standardizing gradacol membranes has not been mentioned in any previous publications.

22. Sedimentation rate of red blood cells in epidemic dropsy.

C. L. PASRICHA, *and* K. S. MALIK, Calcutta.

(*Epidemic Dropsy Enquiry, Indian Research Fund Association.*)

The sedimentation rate of red blood cells, the cell volume and the haemoglobin content have been estimated in a series of 74 cases of the natural disease and in eight persons in whom symptoms resembling those of epidemic dropsy were produced following the intake of mustard oil containing argemone oil.

The sedimentation rate of red blood cells is increased in epidemic dropsy and this test is useful in ascertaining the diagnosis and prognosis. There was not a single case of established epidemic dropsy in which the sedimentation rate was not increased. As a rule the lower the rate, the severer the disease and the worse the prognosis.

In an outbreak of epidemic dropsy in a closed community evidence was obtained suggesting that the increase in sedimentation rate occurs even before the development of the clinical disease. This simple test which can be readily carried out in routine clinical examination is capable of revealing tissue damage long before the development of symptoms. This test would be a valuable one in epidemiological studies.

Fibrin-nitrogen content was established in a series of 20 cases of epidemic dropsy. The results suggest that the sedimentation rate, the cell volume and the fibrin content are inter-related. An increase of fibrin leads to an increase in the sedimentation rate, provided the cell volume is constant. An increase of cell volume decreases the sedimentation rate, provided the fibrin content is constant.

23. Residual infectivity of lymph nodes in tuberculosis.

S. R. GUHA-THAKURTA, Calcutta.

(*Tuberculosis Enquiry, Indian Research Fund Association.*)

For the endogenous re-infection in adult tuberculosis the offending organism of the first infection must persist in the viable stage in the primary parenchymal or glandular focus for subsequent dissemination under unfavourable conditions. The present investigation was undertaken to find out the incidence of infective viable bacilli in the lymph nodes—cervical, tracheo-bronchial and mesenteric of apparently healthy individuals who died of accidental injury or diseases other than tuber-

culosis. The materials were obtained from 140 post-mortem cases of which 57 cases showed some lesion either definite or suggestive of tuberculosis. Twenty-seven or 47% of the cases with lesion and 20 or 24% of 'no lesion' group showed viable bacilli in one or more of the lymph nodes. Thus living bacilli could be demonstrated in the lymph nodes of apparently healthy individuals in 33·5%—a high percentage showing the possibility of endogenous dissemination at any moment of life favourable for its spread.

24. Further studies on the Pityrosporon of Tinea versicolor and Pityriasis capitis. A new oil medium for enhancement of the growth of the organism.

G. PANJA, Calcutta.

The new medium for enhancement of the growth of the Pityrosporon consists of an ordinary nutrient agar or dextrose agar on which a fixed oil such as cocoanut or olive oil has been added. Fine pin point colonies of the organism assume the colony size of an ordinary yeast in 24 to 48 hours. Such a luxuriant growth is most suitable for the study of morphological variations, biochemical reactions of the fungus and immunological experiments that have been carried out. The medium does not enhance the growth of any other organism or yeasts. Volatile oils do not stimulate the growth; on the contrary, they inhibit it. A precipitating antigen has been obtained by boiling the organism in distilled water for 3 to 4 hours. A therapeutic advance has been made based on this new culture medium.

The organism is nontoxic to laboratory animals.

Some clinical features of the diseases caused by the Pityrosporon have been studied.

A discussion on the rôle of the Pityrosporon in the etiology of Tinea versicolor, Pityriasis capitis and Seborrhoeic dermatitis.

Pharmacology and Therapeutics

25. The effect of administration of large doses of vitamin C in haemoptysis in pulmonary tuberculosis.

S. K. ROY *and* M. N. RUDRA, Patna.

The effect of administration of large doses (100 to 200 mgs.) of vitamin C by intravenous injection to haemoptysis cases in pulmonary tuberculosis has been studied. 50% of the patients given vitamin C show considerable improvement as compared to controls in similar circumstances. The course of haemoptysis may be modified to some extent, but no decided action has been apparent.

26. Activity of sulphamethyl thiazole against pneumococcus infection.

A. N. BOSE, S. J. DAS-GUPTA *and* U. P. BASU, Calcutta.

In continuation of a previous work (De and Basu, *Ind. Jour. Med. Res.*, 1938, *26*, 537), certain thiazole derivatives of sulphanilamide have been prepared. The present work deals with the activity of 2-sulphanilamido-4-methyl thiazole against pneumococcus type I infection in mice.

By oral administration of the above compound in 2 per cent gum tragacanth suspension as well as by injecting the same subcutaneously to mice of average weight 22–25 g. a definite protective action is being

noticed. By a comparative therapeutic activity this product is being found to be as active as sulphapyridine (*cf.* Litchfield, White and Marshal, *Jour. Pharm. Exp. Therap.*, 1940, *69*, 166). The drug is being well-tolerated by the animals and no untoward symptoms have yet been noticed. Further work regarding its chronic toxicity and effect on body tissues and organs is in progress.

27. Vitamin and its therapy.

N. K. BASU, Calcutta.

Some new clinical uses of vitamins are described in the paper, particularly the use of vitamin B_1 and B_2 combined together for the cases of leprosy, vitamin C in vomiting of typhoid and pregnancy, vitamin D in various skin diseases and vitamin E in uterine diseases. Failure of vitamin therapy is due to (1) that deficiency diseases are allowed to advance to such an extent that at that stage vitamins can exert very little influence, for experiments on lower animals have shown that up to certain stages in the pathological changes of the systems, vitamins can prove effective. and vitamins have very little direct action on the infective organisms but these act indirectly by raising tissue-resistance; (2) we cannot select proper type and dose of vitamin for treatment; (3) rapid deterioration of the strength of vitamin preparations; (4) sunlight plays a very important part in the absorption of vitamins, particularly with A and C our body requires sunlight for absorption and action in the system; (5) some peculiar antagonism in physiological action between fat-soluble and water-soluble groups of vitamins has been very frequently noticed in our patients, hence it is advisable that these two groups of vitamins would be better prescribed on alternate dates. For normal persons, fresh articles of food are no doubt the best sources of vitamins; but for diseased persons where big doses of vitamins are essential, there can be no alternative for vitamin therapy.

28. Present status of our knowledge of the indigenous medicinal plants of Travancore.

N. K. B. KURUPP, Kayamgulam (Travancore).

The object of this paper is to give an idea of the present status of our knowledge of the indigenous medicinal plants of Travancore. The various difficulties that confront the 'medicine collector' and the physician are described in detail. The number of species of medicinal plants representing 124 families—under which the several known medicinal plants could be grouped—are clearly shown in the table.

29. Effect of sulfanilamide group of drugs on blood.

(MISS) S. CHAUDHURI, New Delhi.

The effects on hemopoeietic system of therapeutic doses of (1) Prontosil soluble, (2) Prontosil album (sulfanilamide), and (3) M and B 693 (sulfapyridine) were studied on monkeys (Silenus rhesus), kept under controlled conditions with regard to diet, etc., in the laboratory. Prontosil soluble was administered by the intramuscular route, and sulfanilamide and sulfapyridine were both given orally through stomach tube.

All the preparations tested produced a definite and progressive anaemia in the animals. Diminution of the amount of hemoglobin and fall of erythrocyte count was found to begin in 24 to 72 hours after the commencement of the administration of the drug and reached a maximum in 7 to 10 days. Mean cell volume of erythrocytes and percentage of circulation reticulocytes were increased and immature red cells were found in the circulating blood of animals treated with prontosil by injection.

Total W.B.C. were decreased under prontosil soluble and sulfapyridine administration.

A study of the concentration of sulfanilamide in the circulating blood was also made and it was found that the maximum concentration was reached in half an hour when the drug is injected and one and a half hours after when the drugs were orally administered. The absorption of sulfapyridine was definitely slower than that of sulfanilamide.

Nutrition and Biochemistry

30. Further observations on the biochemistry of cholera.

HEMENDRANATH CHATTERJEE *and* SURATH MOHAN GHOSH, Calcutta.

(1) A high phenol content of blood was observed in all cases of cholera before administration of saline and in 70% of cases of cholera after the administration of saline transfusion.

(2) The specific gravity of blood comes down to normal with the transfusion but the increase of phenol persisted in many cases.

(3) Early and comparatively mild cases of cholera receiving prompt treatment showed a rapid return to normal specific gravity and phenol content of blood.

(4) There was a diminished reserve alkalinity of the blood. This persisted even after the specific gravity and phenol content of blood became normal.

(5) The clinical improvement runs parallel with the improvement of the blood chemistry.

31. An observation on the phenol content (free, conjugate and total) of blood in normal Indians.

HEMENDRANATH CHATTERJEE *and* JAMINI KANTA SARKAR, Calcutta.

On estimation of phenols (free, conjugate and total) of blood in normal Indians, the following average results were obtained (Theis and Benedict method):

Free phenol—2·24 mgm. per cent.
Conjugate phenol—0·39 mgm. per cent.
Total phenol—2·63 mgm. per cent.

32. The estimation of nicotinic acid content of foodstuffs by an adsorption method.

K. V. GIRI *and* B. NAGANA, Vizagapatam.

An adsorption method for the estimation of nicotinic acid content of yeast, animal tissues and other foodstuffs is described. Nicotinic acid is quantitatively adsorbed by medicinal charcoal. By eluting the charcoal adsorbate with hot alcohol-sodium hydroxide solution, an eluate is obtained that contains the vitamin. The charcoal adsorption and elution method is applied to a number of foodstuffs and animal tissues and added nicotinic acid is quantitatively recovered from them by such treatment.

33. Investigations on the biochemistry of leprosy.

C. S. VENKATASUBRAHMANYAN *and* K. V. GIRI,
Vizagapatam.

In view of the recent findings by several workers on the importance of nutrition in relation to the etiology of leprosy, an experimental enquiry on the biochemical changes in the blood in leprosy has been undertaken. Investigations on the changes in calcium, phosphorus and phosphatase of serum in 21 cases of leprosy, have shown that the values were usually within normal limits. The calcium content of the blood varied from 8·7 to 12·3. The inorganic phosphorus values were 2·52 to 6·4, and the phosphatase values varied from 0·41 to 3·1 Bodansky units. Although the values obtained for total proteins were within normal limits, the albumin-globulin ratio was altered in almost all the cases (13) investigated. The values for total proteins varied from 5·2–7·4; the average being 6·0. In all the cases there was an excess of globulin over albumin fraction.

34. The state of vitamin C nutrition in pulmonary tuberculosis.

S. K. ROY *and* M. N. RUDRA, Patna.

The state of vitamin C nutrition in 60 cases of pulmonary tuberculosis patients (males and females) has been studied. They show a state of considerable vitamin C subnutrition. Administration of 250 mgs. of vitamin C by mouth show that vitamin C in natural form (sun dried Emblica officinalis pulp) has a comparatively better effect than synthetic vitamin C (Redoxon 'Roche') in bringing pulmonary tuberculosis patients to state of saturation with vitamin C. This better effect by natural vitamin C is ascribed to the probable presence of vitamin P in Emblica officinalis.

35. On iron and copper metabolism.

K. P. BASU *and* B. GUPTA, Dacca.

Typical rice or whole wheat (atta) diets contain sufficient iron for the maintenance of positive balance in normal adults.

Calcium was supplemented to the basal diet in the form of Ca-lactate, gluconate, lime, milk and calcium from three vegetables, viz. amaranth, ladies' finger and drumstick, which are known to be very rich sources of calcium. In most cases, extra ingestion of calcium was accompanied by more excretion of iron in the faeces. Milk calcium did not show this antagonistic effect to any appreciable extent.

Our experiments with three normal subjects taking large doses of iron every day, show that the body has a considerable storage capacity for iron. At physiological levels of intake, iron excreted with the faeces is nearly equal to the amount in the food, but with large intakes of iron, a considerable portion of the ingested iron is always retained.

The daily copper requirement of an adult appears to lie between 2-3 mg. Typical Indian dietaries always supply the requisite amount and in none of the experiments was any of the experimental subjects in negative copper balance. The effect of administration of extra amount of calcium almost always resulted in increased excretion of copper.

36. Assessment of vitamin A deficiency of Bengalis by a simplified method.

N. M. BASU *and* N. K. DE, Calcutta.
(*Indian Research Fund Association.*)

A simple method of assessment of vitamin A deficiency by the determination of the final light threshold value during dark adaptation was evolved in the laboratory. This method was applied in assessing

vitamin A deficiency amongst 361 school students of different economic status, 161 employees of moderate income and 171 patients with eye lesions. The students and employees were apparently of good health. It was noticed that nearly 77% of school students had a high reserve of vitamin A in their body, but amongst the employees only 40% had the same reserve. Amongst the patients, curiously enough, some showed a good store of vitamin A. On daily administration of 10,000 I.U. of vitamin A to some of these patients for a month or more, symptoms, such as phrynoderma, xerosis, kerato-malacia, and night-blindness, were either completely cured or very distinctly ameliorated, but no change took place either in Bitot's spots or pigmentation of the conjunctiva.

In ascertaining the perception of final threshold values of light during dark adaptation of students and employees, it was noticed that a large majority of students showed a value corresponding to 0·0051 milli-foot-candle and similarly a large proportion of employees showed a value equivalent to 0·0114 milli-foot-candle. Accordingly, these values are considered to be normal for students and adults respectively. Subjects showing values lower than these standards are taken to be deficient.

37. Determination of optimal and normal requirements of vitamin A by adults.

N. M. BASU *and* N. K. DE, Calcutta.

(*Indian Research Fund Association.*)

Researches by hosts of workers have established the relationship between visual purple in rods and increase in the sensitivity of retina (i.e. its power of light perception) in the dark and also the relationship between the supply of vitamin A to the retina and the regeneration of visual purple in the dark. Accordingly, the vitamin A reserve in the body, upon which the vitamin A supply to the retina depends, is assessed by ascertaining the light perception value during dark adaptation.

In consideration of these facts the maximum light perception values of persons after they are saturated with vitamin A by prolonged intake of 10,000 I.U. of vitamin A daily, are determined. It was noticed that this value is the same, viz. 0·0023 milli-foot-candle in the cases of all saturated persons and that after the attainment of this value, a steady state is reached, for it cannot be increased by further administration of larger doses of vitamin A. It was argued that the minimum intake of vitamin A which would maintain this value of the power of light perception in the dark is the optimum requirement of a person. It is found in this way by experiments with different persons that 5,000 I.U. of vitamin A per diem is the optimum requirement. By similar experiments with different persons it is found that the intake of 4,000 I.U. of vitamin A per day is necessary for maintaining the dark adaptation value at 0·0051 milli-foot-candle, which has been taken to be the normal value for children and the intake of 3,000 I.U. of vitamin A per day is necessary for the dark adaptation value at 0·0114 milli-foot-candle which has been taken to be the normal value for adults. Thus the normal requirements of vitamin A for children and adults are 4,000 I.U. and 3,000 I.U. per day.

Different diet charts which would provide daily 5,000 I.U., 4,000 I.U. and 3,000 I.U. of vitamin A have been constructed.

38. Destruction of insulin in blood.

N. K. IYENGAR, Calcutta.

Insulin when injected into normal or diabetic subjects appears to work only for a limited time. There is therefore apparently a mechanism for the destruction of the hormone in blood during circulation or for its

removal from the body. Previous workers have obtained evidence that the neutralizing principle is an enzyme, possibly trypsin, which is inactive in acid solution.

A comprehensive study of the proteolytic enzymes in the various fractions of blood has been made to throw light on the above problem. A comparative study of the red cells, plasma and platelets show that the platelets possess the highest proteolytic activity. The determination of the optimum *p*H for activity of the enzyme shows that it is tryptic in nature. The dried platelets werė found to be most active in destroying insulin. The digestion of insulin protein and the corresponding destruction of the potency of insulin by a buffer extract of dried platelets, has been followed.

Thrombin has no inactivating power on insulin. The evidence for the possibility of the platelets being responsible for the physiological destruction in the circulation, has been discussed.

39. Serum phosphatase in experimental liver damage.

K. B. SEHRA *and* B. MUKERJI, Calcutta.

The blood serum phosphatase values have been studied in a series of days in which experimental liver damage and biliary obstruction were artificially induced, the former by the gradual oral administration of hepatoxic doses of carbon tetrachloride and the latter by ligating the common bile duct through a laparotomy wound in anaesthetized animals. It has been found that in practically all cases with primary damage of the liver there is a sharp rise in the serum phosphatase values. In hepatocellular damage by carbon tetrachloride, the values are found to vary from 16 to 20 Bodansky units or sometimes even less. In biliary obstruction, the values are usually higher than 25 Bodansky units, the maximum value recorded being 110 units.

High phosphatase values (30 Bodansky units or above) may usually be taken as indicative of obstruction in the biliary system. From the phosphatase level of blood serum, liver damage with or without obstruction in the biliary system may be easily diagnosed even before appreciable signs of jaundice supervene. The significance of the findings is discussed in relation to jaundice and similar clinical conditions.

40. Urinary excretion of nicotinic acid in pellagrins.

K. V. GIRI *and* B. NAGANNA, Vizagapatam.

Harris and Raymond method (*Biochem. J.*, 1939, **33**, 2037) for the estimation of nicotinic acid content of urine has been modified to suit the ordinary colorimeter. With this method the urinary excretion of nicotinic acid plus nicotinamide expressed as nicotinic acid was determined. It was found that the nicotinic acid content of the urine of pellagrins was practically nil, and increases somewhat when the patient is put on hospital diet composed of milk and bread. Administration of 50 mg. of nicotinic acid daily raised the nicotinic acid content to normal value within three or four days, when all the typical symptoms of pellagra disappeared. The results indicate that the estimation of the nicotinic acid content of urine affords a valuable and probably an earlier diagnosis of pellagra.

41. Investigations into the epidemiology of epidemic dropsy—isolation of active substances from toxic oils.

S. P. MUKHERJI, R. B. LAL, *and* K. B. L. MATHUR, Calcutta.

(*Inquiry financed by the Indian Research Fund Association.*)

A white crystalline organic compound (reacting substance) has been isolated from non-saponifiable fractions of samples of mustard oil

epidemiologically associated with outbreaks of epidemic dropsy as also from oil expressed from seeds of *Argemone mexicana.* This substance is responsible for the differential, physical and chemical tests for specifically toxic oils. It gives alkaloidal reactions, leaves no ash on micro-inceneration and melts at 188-189°C. The empirical formula worked out by micro-chemical method is $C_{18}H_{15}O_4N$. The specific gravity is 1·42 at 30°C. This compound cannot be obtained or can only be obtained in minute quantities from mixtures of mustard oil and argemone oil which have become non-reactive to the differential tests through treatment with appropriate physical and chemical reagents.

A similar free base has also been obtained from ethereal solution of argemone oil by passing HCl-gas and washing the light yellow deposit with water or dilute liquor ammonia. It has been purified by repeated recrystallization with absolute alcohol and benzene or toluene. It melts at 190°C. Besides reactivity to the specific tests the substance has many properties in common with the reacting substance described above.

The biological properties of the substances are discussed in a separate communication.

Anatomy and Embryology

42. Early recognition of sex in human embryos.

D. S. Deshpande, Bombay.

The external genitals in human embryos are discernible on the 40th to 47th day and for six or seven days more the external sex characters are indifferent. The chief characteristics by which the sex can be determined at this stage are erectness of the phallus, the length of the urethral groove and the relations of the urethral folds to the labio-scrotal swellings. Often these criteria are not perfectly reliable as proved by microscopical examination of sex glands. There is always a liability to error in diagnosing retarded males or females. But if the following characters are taken into consideration it is always possible to determine the sex a week earlier and that too without any possibility of error even on microscopical examination. Firstly, one should consider the ano-genital distance in the embryos. It is always greater in male than in female of the same age. Secondly, the genital papilla is always larger than the female papilla of the same age. Identification of a dozen embryos by this method will give one the master key to the earliest sex determination in human embryos.

43. On the gigantism of umbilical hernia.

D. S. Deshpande, Bombay.

Oftentimes the retraction of the mid-gut loop fails to return from the extra-embryonic coelom and the result is the umbilical hernia. This case is peculiarly of interest because the whole mid-gut loop remained and developed outside the intra-embryonic coelom. The foetus except but gigantism of umbilical hernia was of normal type and the age determined was approximately six months. The length of the hernia from the open umbilical orifice was 18 inches and the approximate diameter at the base was 4 inches, which gradually reduced to the apex where it was only 2 inches. On dissection the foetus presented the structures just like those of the 5th week embryo, i.e. before the rotation of the gut. The loop had a convexity forward, and the apex protruding a shrivelled up yolk sac with fine thread like vitello-intestinal duct. The pre-arterial and post-arterial mesentery was well differentiated but the termination of the superior mesenteric artery abnormally thickened. Here the abdominal parietes form, so to say, a big U-shaped sink in which the whole development had taken place and persisted. On close study it was found that the

pre-arterial loop and mesentery after the first stage of rotation formed adhesions which resulted in the non-retraction and formation of giant umbilical hernia.

44. On the embryonic regression of palmar and plantar pads in man.

D. S. DESHPANDE, Bombay.

There is a tendency for human palmer and plantar pads to undergo regression as compared to monkeys and other lower mammals. These pads trace their origin to the generalized mammal of insectivore type. In the foetal condition of all these animals all the pads are well developed having wide expanse variously conjoined with the neighbouring pads. In the human embryos of 3 or 4 months all the areas show similar growth marks but later on they gradually recede and get diminished in size and their place is taken by the variety of designs, such as loops, double loops and whorls. After examining many embryonic specimens one comes to the conclusion that no two individuals present duplicate configurations even in the foetal conditions and is also probable that the unlikeness holds true even for small homologous areas.

45. A study of epiphysial union in Bengalee boys.*

S. K. BASU *and* G. S. CHATTERJEE, Calcutta.

This study is in part complementary to that in Bengalee girls by the senior author and Dr. Sudhir Basu. It was carried on roentgenographically on (more than one half the cases by the second author) 150 Bengalee boys. The subjects were selected from economically stable families of higher caste Hindus. Such children were reared on a balanced diet with a plentiful supply of milk. Their ages were carefully verified from horoscopes and other family records. The results arrived at differ in chronological value from those of researches in other parts of the world,—epiphysial union being found to be more precocious in this work. The pattern and sequence of epiphysial union, however, remain practically the same. Differences are also noticeable from results of previous workers in this country, who did not select their subjects from one community or from those with a standard of rearing close to the scientific ideal. The present work therefore does not represent an average of results from subjects recruited at random but is a nearer approach to the scientific standard of accuracy. It also throws open an incentive to workers in other communities for similar investigations in order the racial, climatic and dietetic influences, if any, on the principles guiding epiphysial union may be established.

46. The problem of right-handedness.

A. ANANTHANARAYANA AYER *and* V. SITARAMA RAO, Vizagapatam.

A survey of present views regarding factors responsible for the causation of right-handedness in the majority of people (95%) is made. The authors have made measurements of the anterior borders of the parietal bones in fifty skulls and it is found that in 70% of skulls the anterior border of the left parietal bone is longer than that of the right. They also cite evidence to show that the central sulcus in the majority of

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* The authors express their grateful acknowledgement for the help rendered by the late Dr. Santosh Kumar Basu who took up the study as a co-worker with the present authors, and who was responsible for major portion of the work.

brains is longer on the left side. From this they infer that the motor cortex of the left side is more extensive and right-handedness is due to the dominance of the left motor cortex. As regards the determining factor causing the dominance of the left motor cortex, it is suggested that the position of the foetus in the mother during the later months of pregnancy might be responsible for it. The intermittent pressure on the foetal head caused by the filling and emptying of the pelvic colon and rectum might cause hypertrophy at the site of pressure In the commonest position L.O.A. the site where this intermittent pressure is likely to act corresponds to the region of the anterior border of the parietal of the left side overlying the left motor cortex. Left-handedness will be due to a lie of the foetus where the right motor cortex is likely to be subjected to the intermittent pressure of the pelvic colon and rectum. Among animals the beginning of right-handedness is seen in the gorilla and also the commencement of fixation of pelvic colon and rectum. Further data giving the lie of the foetus along with the right- or left-handedness of the child will substantiate or disprove the suggestion.

47. Anterior commissure of the forebrain in the hedgehog (*Erinaeceus europeus*).

Y. Appajee, Mysore.

A detailed study of the anterior commissure of this animal is made wherein the writer has made the observation that this commissure is still a neopallial commissure to a great extent as in the case of marsupials and other lower vertebrates. A large part of the interbulbar or olfactory component is made up of the neopallial fibres from the frontal cortex. The rest of the non-olfactory cortex sends commissural fibres through the external capsule to the anterior commissure. The writer thereby confirms the theory of late Prof. Sir Grafton Elliot Smith, that, as we ascend the scale in the vertebrate series, the neopallial commissural fibres take a new dorsal pathway in the lamina terminalis and form the corpus callosum and leave the anterior commissure to form the pathway for the olfactory commissural fibres only, and that in the low mammals like insectivores, etc., a transition stage is likely to be seen where the neopallium utilizes both the dorsal and the ventral pathways for its commissural fibres.

48. The carrying angle of the elbow in South Indians.

A. Ananthanarayana Ayer *and* V. Sitarama Rao, Vizagapatam.

The cubital angle, the joint-axis angle and the carrying angle have been measured according to standard anthropometric technique in 20 sets of humerus and corresponding ulna of South Indian males. The mean values are, cubital angle, 84·8°; joint-zxis angle, 81·3° and the carrying angle, 166°. The right side angles are generally larger than those of the left side. The values for the carrying angle of South Indians agree with the values given for Europeans in standard text-books of Surgery and Anatomy.

B. VETERINARY RESEARCH

Pathology and Bacteriology

49. Encephalo-myelitis in animals in Hyderabad State.

M. R. Mahajan, Hyderabad-Deccan.

The paper records an acute outbreak of equine encephalo-myelitis in the District Police Lines and city of Hyderabad. Investigation that

was confined to the Police Lines, recorded 21 attacks out of a total of 57, with a loss of 12 horses. Cerebral, spinal and mixed cerebro-spinal forms of the disease were encountered. Horses involved were 17 Australians and 4 country-breds. Eight cases discovered in the early stage of the attack, recovered and one remained as a hopeless case of spinal type (Kumri). Diagnosis was established locally and this was confirmed by the Imperial Veterinary Research Institute, Mukteswar. The existence of 'Carriers' was responsible for prolonging the outbreak from October 1939 to August 1940. Complications of Strongylosis and Piroplasmosis in the horses involved (the latter perhaps a resuscitation) also required attention. Paper also records the occurrence of some sub-acute and chronic outbreaks of the disease in bovine and caprine animals. 'Circling disease' of ovines as known in Hyderabad is also now thought to be an encephalo-myelitis, which occurs in a per-acute form, in the rainy season, in a widespread area. *

50. Experiments upon the transmission of bovine haemorrhagic septicaemia through the agency of the flea, *Ctenocephalus felis*.

G. K. MEHRA, Mukteswar.

The only record of successful transmission of haemorrhagic septicaemia by arthropods is that of Daubney, Hudson and Roberts (1934), who showed that haemorrhagic septicaemia was transmissible from mouse to mouse through the agency of *Ctenocephalus felis*.

The writer tested the possibility of the disease being conveyed from rabbit to rabbit, through the agency of the same species of flea. It was found that, in the absence of fleas, close contact or cohabitation of the infected animals with the healthy does not give rise to the disease in the latter.

Healthy rabbits living in flea-proof cages died of haemorrhagic septicaemia conveyed to them by infected fleas from an adjacent cage which contained a diseased animal.

Fleas were collected from infected rabbits, washed repeatedly to remove external contamination, crushed and filtered through a fine muslin. The infectivity of the emulsion thus obtained was tested upon a healthy rabbit with positive result.

Smears from infected fleas proved on microscopical examination to be positive for the presence of pasteurella organisms.

The work is being continued in large animals as well.

51. On the systematic position of *Rhinosporidium seeberi*, Wernicke, 1903.

S. DATTA, Mukteswar.

Researches hitherto carried out upon this organism have been concentrated upon the solution of the difficulties attending its cultivation, and the experimental transmission of the disease. Attempts to reproduce the disease with infective material on monkeys, rabbits, guinea-pigs, mice and calves have invariably yielded negative results. Workers have failed to cultivate the organism, except in one or two doubtful instances.

The writer has been successful in cultivating the organism from human material received from Poona and Madras. In the course of this work indications have been obtained suggestive of the possibility that *R. seeberi* represents a developmental stage of a fungus belonging to the group of Aspergilli, the most important of these indications being the production of characteristic Rhinosporidium 'sporangium' on the mycelia. The infectivity of the cultures has been tested on both large and small animals with encouraging result.

52. Experimental attempts to induce *Corynebacterium equi* to produce a toxin.

V. R. RAJAGOPALAN, Mukteswar.

Several attempts were made to induce *Corynebacterium equi* to produce a toxin in artificial media. The conditions so far provided do not appear to be conducive to toxin production *in-vitro*.

Entomology and Parasitology

53. A new species of *Subulura*, *S. minetti*, *n.sp.* (Nematoda) from an Indian fowl.

G. D. BHALERAO, Izatnagar.

This new species occurs in the intestine of the host and has a distinct œsophageal bulb, 10 pairs of caudal papillæ, fusiform pre-anal sucker measuring 0·182–0·277 mm., equal spicules 1·085–1·19 mm. long, gubernaculum 0·169–0·223 mm. long. The vulva is situated on a small prominence, between the anterior two- to three-sevenths of body. The ovijector is characteristic. The eggs measure 0·056–0·095 × 0·038–0·062 mm.

54. On some trichostrongyles of domestic ruminants in India.

G. D. BHALERAO, Izatnagar.

Trichostrongylus colubriformis has been recorded from goats and sheep at Mukteswar, Poona and Lahore. Some modifications of the branching of the dorsal ray are noted. *T. extenuatus* has been recorded for the first time in India, from the abomasum of goats at Mukteswar. In addition to the typical forms of this species, a few males were obtained in which the dorsal ray bifurcates at its posterior third. *T. probulurus* has been recorded from the abomasum and small intestine of sheep and goats at Lahore. *Cooperia pectinata* has been recorded from the abomasum of cattle and the intestines of goats at Mukteswar. Daubney's observations on the spicules in this species are confirmed. *C. punctata* has been recorded from the intestines of cattle and a goat at Mukteswar. The specimens of this species at the disposal of the writer were considerably larger than those previously described. The internal organs, however, fall within the range of variations previously recorded. *Ostertagia ostertagi* has been recorded from the abomasum of cattle at Mukteswar and many deviations from the forms previously described are noticed. The validity of *Marshallagia orientalis* is re-stated. *Camelostrongylus mentulata* has been recorded from sheep and goats for the first time. *Hæmonchus longistipes* has been recorded from sheep for the first time.

In all cases, observations are recorded on all important parts of anatomy.

55. Records of the occurrence of warble-flies (*Hypoderma lineatum* De Villers and *Hypoderma crossii* Patton) in Sind.

B. N. SONI, Mukteswar *and* H. S. BAWA, Karachi.

A warble-fly survey of Sind was undertaken by the writers during the winter of 1939-40. A widespread occurrence of *H. lineatum* among cattle and of *H. crossii* among goats was recorded in certain districts. *H. crossii* infestation was most common in the districts adjacent to Baluchistan, but maritime areas were practically free of infestation. A map showing the geographical distribution of the two species of warble-flies in Sind is included in the article.

56. Abnormal development of malarial oöcysts in mosquitoes.

B. C. BASU, Mukteswar.

Mosquitoes referred to in this note were laboratory bred *Anopheles stephensi*, fed on gametocyte-carriers of Indian strain of human malaria and an abnormal development of a proportion of the oöcysts was noted in the serial sections of the mosquitoes.

(i) In some of the fed mosquitoes (especially in malignant tertian infections) oöcysts packed with sporozoites were found developing towards the lumen of the midgut. Such oöcysts apparently rupture into the gut and the sporozoites liberated cannot have any chance to invade the salivary glands, and as such, the mosquitoes concerned could not be infective. Thus an infected mosquito is very different from an infective mosquito.

(ii) In some mosquitoes (with quartan and malignant tertian infections), pigmentary degeneration of the oöcysts occurs, thus producing the 'black spore' of Ross—the pigment being derived from the parasite and not from the mosquito tissue.

(iii) In a few mosquitoes (with benign tertian infection) an appearance was noted, as if the whole protoplasmic contents of oöcysts had divided into two equal masses—the appearance rather recalling that which occurs in oöcysts of the Isospora coccidia. It is probable that in such cases two zygotes settle down so close together that they form a common cyst.

The work was conducted at the Calcutta School of Tropical Medicine with a grant from the Indian Research Fund Association.

57. Free-living stages in the life-history of *Mecistocirrus digitatus*, a nematode causing parasitic gastritis in cattle.

P. B. KUPPUSWAMY, Izatnagar.

The eggs when laid by the female are in the morula stage. A full grown embryo is developed after 12 to 20 hours. The embryos hatch out of the eggs from 29–48 hours after they are laid.

In the life-cycle of this parasite three distinct stages are noticed during the pre-parasitic life. The first and the second stage and a part of the third stage are completed outside the body of the host.

The first stage, in which the larva is rhabditiform, lasts for 2–4 days, depending upon the circumstances. During this period the larva becomes ensheathed. Two sub-stages, an active sub-stage followed by a lethargic sub-stage, are noticed.

The second stage commences after the first ecdysis. This stage lasts for 2–5 days. During this period the larva again becomes ensheathed. A few changes take place during this stage. Two sub-stages are noticed in the second stage also.

The third or the infective stage commences soon after the second ensheathing. The infective larvae were kept alive in cultures for a period of two months. No ecdysis was observed even after such a long period. No further progress of the larvae was noticed in cultures.

An appearance of a thin cord-like attachment between the head of the advanced ensheathed first stage larva and the anterior portion of the sheath was noted. The presence of two small dark brown circular bodies at the anterior end of the oesophagus of the third stage larva was a constant feature.

A detailed account of the anatomy and biology of each stage is given.

Nutrition and Biochemistry

58. The stability of carotene in pasture grasses.

P. A. SESHAN *and* K. C. SEN, Izatnagar.

In a previous paper from this laboratory (Sen and Seshan, *Indian Journal of Veterinary Science and Animal Husbandry*, **1938**, **8**, 169), a review of the problem of vitamin A deficiency in farm animals was made and it was concluded that so far as India was concerned the only practicable way of meeting the vitamin deficiency was by introducing green feed as a regular component of the diet of these animals. It is a well-known fact that green plants contain only carotene and no preformed vitamin A as such. Hence the vitamin A supply of farm animals is determined by the sufficiency or otherwise of the amount of carotene ingested through the feed. The carotene content of pasture grasses thus acquires a high significance in the nutrition of farm animals. Several factors seem to affect the carotene content of grasses and hence a detailed study of the stability of carotene under various conditions has been initiated in this laboratory. This paper presents the results of a study of the effect of heat on the stability of carotene.

Experiments show that heat by itself is not able to destroy carotene when grasses are dried by heating. When a fresh sample of Dub grass or Elephant grass is heated at 100°C. for a couple of hours in vacuo, no loss of carotene is observed. Samples of grass after heating in an autoclave for one hour, show no additional losses when heated in vacuo at 100°C. for another two hours.

In the presence of air, a similar heating at 100°C., however, causes significant losses, namely about 40 per cent in two hours and 90 per cent in 24 hours. Autoclaving for 1 hour under 2 atmospheres pressure shows a destruction of 20 to 30 per cent of the carotene in fresh samples. When autoclaved samples and vacuum dried samples are further heated in a hot air oven at 100°C., there are distinct losses. These experiments show conclusively that atmospheric oxygen plays a definite rôle in the destruction of carotene.

Further investigations are in progress with reference to the parts played by sunlight and enzyme action in the destruction of carotene, on drying grasses.

In connection with this study, a method of carotene estimation has been developed in this laboratory. The modifications introduced appear to give more quantitative and consistent results.

SECTION OF AGRICULTURE

President :—K. Ramiah, M.B.E., M.Sc., Dip.Agri. (Cantab.), L.Ag.

Agricultural Meteorology

1. The direct utilization of solar energy.

L. A. Ramdas, Poona.

The paper discusses the possibilities of utilizing solar energy directly for given practical purposes. The available data on the intensity and duration of sunshine in India are summarized. Over the greater part of India the hours of bright sunshine exceed 50% of the possible hours from January to May and again from October to December.

Simple calculation shows that about 10 sq. metres of receiving surface may be required for developing one horse power out of incident solar radiation after allowing for losses. The attempts of different scientists to harness sunshine to drive mechanical engines are next described. Abott's solar cooker and other possible applications are briefly dealt with and attention drawn to the great scope for further investigations on the utilization of solar energy.

2. Seasonal variation of soil moisture in relation to rainfall.

L. A. Ramdas, A. K. Mallik, *and* K. M. Gadre, Poona.

Weekly determinations of soil moisture from the surface to a depth of 18 in. are being made from a bare plot in the Central Agricultural Meteorological Observatory, Poona, for the last five years. The simple method of taking samples with a soil auger and desiccating these to dryness at 100°C. was used for the actual determination of the percentage of water in the soil. Results presented show that there is a rapid fluctuation of moisture near the surface of the soil during the rainy months but later during the clear season (November–April) a steady state is reached when the surface soil contains only hygroscopic moisture. Once this stage is reached there is not much variation in the moisture content of the soil from day to day as the surface regains by absorption at night what is lost by evaporation during the day. The protective influence of a top layer of dry soil on the moist layers underneath thus finds an explanation.

3. Frequency of high temperatures in India.

L. A. Ramdas *and* P. V. Pimpalwadkar, Poona.

The frequencies of maximum temperatures higher than 90°, 95°, 100°, 105°, 110°, 115° and 120°F. have been computed for 60 selected stations for a period of 10 years (1920–29) for the different months of the year. From these the mean frequencies have been calculated. Maps of India showing the distribution of the areas with frequencies >100°, >105°, >110° and >115°F. have been prepared. These charts show clearly how the areas of high maximum temperatures develop and move during the course of

the year. As plants have to experience these variations of temperature, the farmer is as much concerned with heat waves as with cold spells.

4. Effect of surface colour on the loss of water by evaporation from columns of black cotton soil resting on a water table.

A. K. MALLIK, Poona.

Samples of Poona soil were exposed in triplicate in soil evaporimeters with the water table at 9″ and 15″ respectively. Two of each set had the surface covered with a thin white cover and black cover respectively. A white cover was found to reduce the rate of evaporation considerably; the increase of evaporation caused by a black cover was not large as the local soil was already almost black in colour. The reduction of evaporation due to the white cover is sufficiently large to be of benefit to plants during spells of drought in places where irrigation is not feasible.

5. The wind-break effect of crops.

P. K. RAMAN, Poona.

The lowering of wind velocity by standing crops offers great self-protection for the plants. Measurements of wind velocity with an Albrecht Hot-wire Anemometer taken at various levels above the ground in the open and in different environments of growing crops are discussed in detail. The wind breaking capacity or the ability to reduce air movements of the different crops within the extent of their respective heights is in the order given below:—

Sugarcane 16%, Wheat 20%, Jowar 30%, Double bean 30%, Cotton 35%, Suran 45%, and Tobacco 50%.

When wind velocity exceeds the limits of safety for a standing crop the crop is laid low and suffers considerable damage by lodging. A typical instance of lodging is also discussed.

Wind-breaks are essential to check the flow of cold air in winter nights across an orchard. After checking the air movement, fires used to heat gardens during nights when frosts are expected are more effective in saving the crop from damage.

Soils and Agricultural Chemistry

6. On the nature of the weathering complex of Indian red soils as determined by the Van-Bemmelen-Hissink method of HCl extract.

S. P. RAYCHAUDHURI *and* M. K. MUKHERJEE, Dacca.

Determinations were made of the percentages of constituents of soils dissolved by boiling hydrochloric acid and of the alkali-soluble silica of the residue after digestion with boiling hydrochloric acid. The silica-sesquioxide ratio of HCl extract of soils from Madras and Assam show a parallelism in general. The percentages of alkali-soluble silica do not show any regular variation down the profiles. In the case of the soil profiles from the Nilgiri Hills it is found that the greater the height from where the soils were collected the less is the quantity of alkali-soluble silica in the soil. The red soils of Assam appear to be of the class of red loams and the soils of Barind Tract are similar in nature to the soils of Assam.

7. Studies on the fixation of phosphates by Indian red soils. I. A short note on the applicability of Truog's method for the determination of available phosphates in Indian red soils.

M. K. MUKHERJEE, Dacca.

The three widely used methods (namely Truog's method, Dyer's method and the acetic acid method) for the determination of available phosphate in Indian red soils have been compared. It was found that any two methods bear fairly good degree of correlation ($r = 1{\cdot}057$, $0{\cdot}88$, and $0{\cdot}979$). Truog's method has some advantages over the other two methods; it takes less time, the change in pH of the solution after extraction is least on account of its being a buffered solution and, as it gives a consistently higher value, it helps better to distinguish between the phosphate status of soils.

8 Studies on the mineralogical constituents of some Indian red and lateritic soils.

S. P. RAYCHAUDHURI, Dacca.

The mineralogical constituents of the fine sand fraction of some profile samples of red and lateritic soils of India have been determined with the help of a petrological microscope. The fine sand fractions were separated into three sub-fractions, viz., heavy (sp. gr. $>2{\cdot}9$), middle (sp. gr. $2{\cdot}9$–$2{\cdot}65$) and light (sp. gr. $<2{\cdot}65$), which were weighed separately and their mineralogical compositions separately determined.

In almost all the soils quartz particles were characterized by rough angular appearance, the grains being rounded by curved fractured surfaces. The common ferromagnesian rock-forming minerals were represented by one or more species in all the soils examined, one or the other being present in preponderating amount. Hornblende was commonly present. Chlorite, an alteration product from the ferromagnesians, was found in most of the soils studied. Biotite was occasionally found (e.g., Nilgiri Hills). Epidote and Garnet were frequently found in granular form, whilst Tourmaline and especially Zircon, though sometimes fragmentary, showed crystalline forms.

Iron ore minerals like haematite, limonite and magnetite were present in all the soils examined. With regard to the percentage of the ferro-silicate group of minerals in the various soil samples, the soils of basic igneous origin were naturally the richest. The mineralogical constituents of the soil types examined, except from those of Bengal, were, however, much similar.

9. Grey and fired soils as soil improvers on normal and eroded land.

A. SREENIVASAN, Indore.

The grey soil that occurs alongside *nallahs* and in low-lying areas adjacent to black cotton tracts in Malwa has been found to be a good soil improver for cotton growth. In replicated and randomized experiments with this soil applied to small plots in a well-drained field, it was observed that replacement of the surface six inches of field soil by half the quantity of grey soil resulted in an increase of over fifty-five per cent in the yield of *kapas*. Replacement in full and with one-eighth quantity of grey soil increased the yield by 47 and 15 per cent respectively over the untreated control soil.

In an eroded field similar replacement in full of the surface six-inch layers of small plots by grey soil gave nearly six times the yield of cotton as compared with the untreated plots. Replacement with one-eighth

quantity of grey soil gave three times the yield. Similar treatment of the surface layers with half the quantity of fired soil gave about twice the yield while application of fired soil in trenches along rows four inches apart was only slightly though definitely better than the control.

There is evidence to suggest that treatments with fired and grey soils improve the structure of field soil.

10. Reclamation of water-logged and eroded soils for cotton cultivation.

A. SREENIVASAN, Indore.

Kharif crops do not succeed well in fields which are subject to severe erosion and water-logging during rains. Trials have shown that treatment with manures does not also give beneficial response in such fields. In a preliminary small plot experiment (replicated and randomized) with soil improvers such as ferrous sulphate, superphosphate and potassium sulphate either alone or in combination with ammonium sulphate or compost, it has been observed that a successful cotton crop can be grown provided protection from surface wash and rise of subsoil water is ensured. In a badly eroded and water-logged field an acre yield of 278 lbs. of seed-cotton was obtained. The effects due to sulphate of ammonia and compost (at 50 lbs. nitrogen per acre) were highly significant over no manure. Compost gave 18·2% increase and ammonium sulphate 32·8%. The latter was significantly superior to the former.

11. Gypsum and potassium permanganate as soil improvers on eroded land.

A. SREENIVASAN, Indore.

Previous trials with cotton on eroded fields having shown that the application of superphosphate gives consistently favourable response, a randomized and replicated small plot test was carried out with a view to ascertaining whether the beneficial effect of superphosphate was due to its gypsum or phosphate component. Superphosphate at 25 lbs. P_2O_5 per acre or an equivalent amount of gypsum was applied along with ammonium sulphate used at the rate of 50 lbs. nitrogen per acre. Applications were made either at commencement before sowing or in August or in two equal instalments before sowing and in August respectively. The results showed that the time of application did not significantly alter the yield. Also, calcium sulphate had no effect on the ammonium sulphate while superphosphate definitely increased the yield thus suggesting that the effect of the latter was probably due to its phosphate.

In another replicated small plot test it was observed that treatment of eroded land with potassium permanganate at 100 lbs. per acre significantly increased yield of cotton over untreated plots, the best improvement being obtained when applied in two equal instalments before sowing and in August respectively. The increase in the yield thus obtained was nearly equal to that brought about by treatment with ammonium sulphate at 50 lbs. nitrogen per acre. The response to permanganate treatment may be due to: (i) an improvement in the physical properties of the soil, (ii) better oxidation of soil organic matter, or (iii) both the causes.

12. Fire-heated soil for field crop of cotton.

A. SREENIVASAN, Indore.

Application of lightly fired black soil along plant rows improves growth and increases yield of the cotton crop in Malwa. Best results

are obtained when the fired soil is applied at the bottom of trenches along alternate rows of cotton, the yield increase in seed cotton being 25 per cent over the untreated plots. Similar application along every fourth row gives an increased yield of about 8 per cent while application along every eighth row does not show any difference from the controls.

A simple technique of preparing fired soil has been evolved and is described.

13. Surface soil thickness and cotton development.

A. SREENIVASAN, Indore.

The thickness of the productive surface layer differs appreciably between rich and poor fields of the same soil type. Replicated tests have been carried out on a well-drained and a poorly drained field to ascertain the depth of the surface soil which it is essential to conserve in order to ensure optimum cotton development. The results have shown that addition of loose, surface soil from the same field increases the yield of cotton in both the fields but whereas in the well-drained field, there is no significant difference in yield for additions of 2″ thick layer and over, the poorly drained field shows increasing differences in yield with increasing additions of surface soil, an addition of a five inch thick layer giving the maximum yield increase.

Addition of surface soil imported from a nearby rich field also increases the yield of cotton in both the fields, the increase being more with a five inch thickness than with a two inch thickness. But importation of surface soil is not superior to addition from the same field and hence not profitable.

These results are important and bear out the value of the conservation of surface soil achieved by erosion control.

14. Examination of certain white patches on gorat soils.

C. C. SHAH *and* D. K. PATEL, Baroda.

White patches are often seen on the alkali lands at several places in Gujrat. Such patches have been investigated and it has been shown that the white material on the surface has a very high percentage of total soluble salts. The barrenness of such patches can be cured by deep cultivation and application of farm yard manure.

15. Sodium carbonate treatment of canal beds for minimizing seepage of water, Part II.

M. R. NAYAR *and* K. P. SHUKLA, Lucknow.

The investigations reported last year (vide *Indian Science Congress Proceedings*, Part III, 1940, page 210) were continued and the following conclusions arrived at:—

(1) The permeability of soils to water is facilitated by : (*a*) low clay content, (*b*) high exchangeable calcium, (*c*) presence of organic matter, and (*d*) presence of calcium carbonate.

(2) A method of getting over the first factor is to employ a lining mixture containing a high proportion of clay. This has been successfully carried out and even a sandy soil has been made practically impermeable.

(3) Sodium carbonate treatment replaces the exch. calcium with sodium, thus converting the soil into sodium soil which is impermeable. 95 to 100% of Ca is replaced by the use of 6% sodium carbonate on the weight of soil.

(4) Sod. carbonate is effective in preventing percolation of water in soils containing humified organic matter. In percolation tubes the organic matter slowly moves downwards and forms an impermeable

dark coloured ring or disc, presumably of sodium humate and other precipitated colloidal matter.

(5) The effect due to the presence of calcium carbonate can be counteracted to some extent by addition of sod. carbonate, but not completely.

(6) Small-scale field experiments in *guls* have shown between 75–80% reduction in seepage by sod. carbonate treatment.

16. A note on volume weight of dry soils *in situ* with a simple method for its determination.

S. D. Nijhawan, Girdhari Lal, *and* Lekh Raj Dhingra, Rohtak.

A method for determining the volume weight *in situ* up to a depth of four feet is described. It consists in hammering down an iron cylinder five feet long and four inches wide in sections of six inches. A thick iron plate with handles on the sides is placed at the top while hammering. A metallic plate with a central tube is used to avoid loose soil on the sides from falling into the hole.

The results obtained by this method are always higher than those obtained by the Box method. Average volume weight of all profiles comes to 1·56, giving a weight of 943 tons per acre-six inches. The volume weight of the lower layers is greatly influenced by *Kankar* because of its high apparent density (2·47). However, when this factor is taken into account, the 'Active volume weight' so obtained is always lower than the volume weight of Kankar-free layers indicating thereby the loosening effect of *Kankar*. This factor together with large pore size and poor water-holding capacity, is expected to have a great influence on moisture distribution. The results of moisture determinations indicate this aspect clearly.

17. A modification of Olsen's method for the estimation of ammoniacal and nitrate nitrogen in soils.

S. D. Nijhawan *and* Girdhari Lal, Rohtak.

A modification in the titration procedure of Olsen's method and its comparison with the usual method are reported. The required amount of 5% boric acid solution is pipetted into the receiver and distillation carried on as usual. Due to its very weak acidity, boric acid does not interfere in the direct titration of the absorbed NH_3 with N/50 acid using cochineal or methyl orange as indicator. Results obtained indicate a fairly close agreement with the usual back titration method, although the results by the direct titration method are slightly higher. The principal advantages of the modification are:—

1. It does away with N/50 NaOH.
2. Boiling of the distillate is dispensed with as CO_2 dissolved in the distillate does not affect titration with acid.
3. Sucking back of a sample during distillation does not spoil the result for that sample as it can again be distilled using more boric acid.

18. Comparative study of the nature of soils under some trees of economic importance in South India.

M. R. Bhimasena Rao *and* B. Sanjiva Rao, Bangalore.

Examination of samples of soils from under *Tamarindus indica*, *Mangifera indica* and *Pongamia glabra* has shown that the soil under *Tamarindus indica* has markedly higher carbon content and base exchange

capacity than those under the other two. Humus formation under *Tamarindus indica* takes place under favourable conditions owing probably to the high calcium content of its leaves.

Study of Crops and Crop Products

19. Competition in mixed cotton crops.

V. G. PANSE *and* K. RAMIAH, Indore.

Several indigenous crops are mixtures of varieties and even of species. The local cotton in Central India is a mixture of Upland (*G. hirsutum*) and *desi* (*G. arboreum var. neglectum*) types. Crop census studies have shown that the two components are in a stable equilibrium and the proportion of the components is characteristic of the tract in which the crop is cultivated.

Grown in pure culture, the Upland cotton suffers from diseases and gives a poor yield. To explain the causes of its continued survival in the mixture, in spite of this apparent disadvantage, experiments are in progress at the Institute. In one set of trials started in 1935-36, the two types have been grown in different degrees of association with each other to study the effects of competition. It has been shown that the Upland cotton suffers significantly less from diseases when grown in close association with *desi*. It also gives a higher yield, frequently at the expense of *desi*. It would thus appear that the advantage that the Upland cotton secures on account of its competition with *desi* in the mixed crop is an important factor responsible for its survival.

20. Studies on soy bean in Sind.

K. I. THADANI *and* R. T. MIRCHANDANI, Sakrand.

Investigations into the possibilities of cultivating soy bean crop in Sind under perennial irrigation system have been carried out at the Agricultural Research Station, Sakrand. Several varieties have been tested and classified into (*a*) Indian (obtained from different places in India and (*b*) foreign varieties (imported from outside).

The foreign varieties are found to have defective germination and are more susceptible to white ant attack than the Indian small seeded varieties. Under Sind conditions the life period of the foreign varieties is shorter than that in their original home.

The foreign big seeded types are more subject to cross pollination than the Indian varieties. The mode of inheritance of flower colour has been determined and found to be governed by single factor—the purple colour being dominant over white.

21. Cultivation of sesamum in Sind.

R. T. MIRCHANDANI, Sakrand.

During recent years the cultivation of *til*, an important kharif crop, has received a severe set back due to certain malformation and damage by leaf roller caterpillar (*Antigastra sp.*). The area under this crop has decreased from pre-Barrage average of 33,000 acres to 5,000 acres in 1939-40. The paper describes the work on this problem mainly on the agronomic side. It has been found that early sown crop (June to mid-July) suffers more from the disease and pest than the crop sown in end of July. Detailed notes on vegetative growth and fruiting of crop in different sowings have been recorded and interpreted. Mention is made of the hardy selections resistant to the pest.

22. New rabi crop for irrigated tracts—sugar beet.

K. I. THADANI *and* R. T. MIRCHANDANI, Sakrand.

With a view to investigating the possibilities of introducing sugar beet crop in the irrigated tracts of Sind, experiments were conducted to determine the range of sowing and harvesting period. The yield of topped roots and their sucrose percentages were recorded for different harvesting dates in different sowings. The results indicate that the crop sown during end of September and whole of October can profitably be harvested from the beginning of March until end of April beyond which the crop cannot be kept on the land due to high temperature prevailing at that time.

23. A manurial experiment on sugarcane: the interactions of nitrogen, phosphate and potash at Jorhat.

H. K. NANDI, L. N. PHUKAN, *and* H. N. PAL, Jorhat (Assam).

A manurial experiment on sugarcane was carried out with all possible interactions of nitrogen, phosphate and potash at three levels each, viz., no nitrogen, 80 lbs. nitrogen and 160 lbs. nitrogen per acre applied in the form of cowdung; no P_2O_5, 60 lbs. P_2O_5 and 120 lbs. P_2O_5 per acre applied in the form of algerian phosphate and no K_2O, 75 lbs. K_2O and 150 lbs. K_2O per acre applied in the form of sulphate of potash. The experiment was conducted with Poj. 2714, the standard cane of the station in confounded design with partial confounding of some second order interactions and with three complete replications of the main treatments.

Both the doses of nitrogen gave significantly higher yields over no nitrogen. The higher dose of 160 lbs. nitrogen per acre gave a significant increase over 80 lbs. but the increase was not proportionate to the dose. The responses due to phosphate and potash were comparatively less but both the doses gave significant increases over no application. In both cases, the increased yield due to the higher dose was not significant over the lower dose. Phosphate acted best with no application of nitrogen. Potash gave steadier increases under almost all conditions. The quality of juice was more or less uniform under all treatments.

24. On planting and earthing up of sugarcane at Jorhat farm.

H. K. NANDI, H. N. PAL, *and* L. N. PHUKAN, Jorhat (Assam).

Two experiments, one with plant canes of P.O.J. 2878 and the other with first ratoon canes of the same variety in the following year, on planting and earthing of sugarcane carried out at Jorhat Farm in the same block with the same number of replications and the same split-plot design, are discussed.

Under the conditions of these experiments planting in trenches (9 inches deep) produced a significant increase in yield of stripped canes (3·34 tons per acre) over planting in flats (trenches 3 inches deep) while with regard to residual effects in ratoon canes, planting in trenches gave an increase of 2·6 tons per acre over planting in flats, the difference approaching significance. As for earthings, differences in yields in plant canes were not significant but in ratoon canes the increase (6·38 tons per acre) produced by earthing twice over 'no earthing' was significant. Earthing twice therefore was decidedly the best for ratoon canes. Further, this gave juice with highest percentage sucrose in both cases.

25. Utilization of the waste products of the sugar industry in the cane fields.

R. C. SRIVASTAVA *and* K. ASWATH NARAIN RAO, Cawnpore.

Large quantities of filter press cake, cane trash and, in some factories, bagasse also which have become available as a consequence of the develop-

ment of sugar industry in India are at present unutilized. They contain valuable manurial ingredients like potash, calcium, phosphate, nitrogen and organic matter; application on the cane fields in the form of compost would obviously be the most suitable use for them. In order to determine the best method which can profitably be adopted by sugar factories and attached farms, different methods of composting with suitable modifications have been tried with these waste products. Conditions for preparing a satisfactory compost with little expense have been worked out.

26. On certain floral characters in sugarcane—II.

N. L. DUTT, M K. KRISHNASWAMI, *and* K. S. SUBBA RAO, Coimbatore.

Continuing the above studies the authors devoted their attention to the time elapsing between the initiation of the rudiments and the full formation of the inflorescence. In the few early flowering varieties that were studied this period was about 51 to 56 days and in the late flowering varieties it was much less and ranged from 28 to 31 days.

At its inception the arrow rudiment has a dome-like appearance and on this longish hexagonal structures appear later. Each of these hexagonal structures gives rise to the pedicelled spikelet. Later, sessile spikelets arise from the base of the rudimentary spikelets. In the early stages the pedicelled spikelets grow faster, the sessile spikelets overtaking them later. This occurs in varieties in which the sessile spikelets open first. In *S. spontaneum* the sessile spikelets always lag behind in growth. The anthers are initiated earlier than the pistil.

As regards the size of the fully-formed spikelets, these were the shortest and narrowest in *S. officinarum* and longest and widest in *S. barberi*. *S. robustum* and *S. spontaneum* occupy an intermediate position.

Data from over eighty varieties revealed no correlation between the length of an arrow and the number of whorls borne on it.

27. New sugarcane seedlings for Orissa.

V. K. BADAMI, Cuttack.

The coastal tract of Orissa, especially the delta of the Mahanadi river, is rich in wild species of *Saccharums*. A new trailing form of *S. spontaneum* with sweet stems and a gigantic form of *S. arundanaceum* have been recently noticed in Orissa. The weather conditions from November to January are quite conducive to sugarcane to flower and set seed in abundance. A large number of Coimbatore seedlings produce seeds freely. The silt-sandy soil with the cool weather during January seems to be very suitable for raising seedlings on a large scale at a comparatively small cost. Subsequent planting and rearing are easy operations.

Numerous exotic canes and Coimbatore seedlings have been tested during the last twenty years. In Orissa there was practically no cane cultivation before the advent of Coimbatore seedlings. It is now fast becoming self-sufficient and over 35,000 acres are under cultivation. There are two sugar factories working. But the quality of the canes is very unsatisfactory. The popular canes now are Co. 213, Co. 513, Co. 421 and Co. 419. They give fair yields of 500 to 700 mds. per acre but the sugar content is low and the glucose is high. Only rab is prepared and stored in pots.

During 1939 over 2 million seedlings were raised from self-set seeds and over 30,000 seedlings were grown to maturity under the most trying conditions. A very high standard of selection was adopted. Only those that had a vigour equal to Co. 421 and had rich juice of over 21·0% Brix were cut and planted. In the breeding-plots there are now nearly 1,200 selections superior to Co. 421. Against 16–18% sucrose and over

0·6% glucose in Co. 421, there are now available seedlings having as much as 22% sucrose and 0·2% glucose. In addition their agricultural and milling qualities are good. The performance of these new seedlings as cut canes is full of promise. Further work is in progress.

Since all canes imported from the south, either from Mysore or Coimbatore do not ripen well and produce rich juice with a low glucose content, it is very necessary to breed new canes in northern latitudes to suit the deltaic and sub-tropical conditions. Seedlings produced here can be easily transported to other cane growing areas in a day or two for planting. It is considered that raising large numbers of seedlings under local conditions and making selections out of them would lead to more promising results in Northern India.

28. Spectrum analysis of mineral contents of fruit parts.

L. SIBAIYA, Bangalore.

Using a high frequency spark discharge of the type employed by Walther Gerlach and Werner Gerlach in their study of biological specimens, the mineral contents of certain fruits—like mangoes, plantains, grapes, oranges and apples—have been investigated spectroscopically. It has been shown that the mineral content differs in different parts of the same fruit and that generally, the outer covering of a fruit is richer in calcium, magnesium, manganese and silicon than the inner pulp.

29. Note on the effect of polishing on the cooking qualities of rice.

C. R. SRINIVASA AYYANGAR *and* C. RAJASEKHARA MUDALIAR, Coimbatore.

Some preliminary experiments conducted to determine the extent to which rice could be polished with maximum expansion on boiling and minimum loss of nutritive substances, are described in this paper.

Two varieties, one with red rice and another with white rice, were polished for varying periods, two to ten minutes. Maximum expansion on cooking was obtained by polishing the grain for two to four minutes resulting in the removal of about 1·5 to 3 per cent of the bran. Chemical analysis of the same samples revealed that polishing up to five minutes did not appreciably affect the chemical composition.

In a second series of experiments, the cooking values of shelled and polished (two minutes) samples of 18 varieties were determined. Cooking of shelled rice resulted in uneven expansion giving a rather pasty mass. Slight polishing (removal of 2 to 3 per cent of the bran), however, definitely improved the cooking qualities. In the latter case the expansion was uniform and the grains maintained their shape. It is concluded that the optimum cooking qualities, retaining almost all the food principles can be obtained by polishing shelled rice to a slight extent.

30. Malting quality of ragi.

S. SRINIVASA RAO *and* B. N. SASTRI, Bangalore.

Seven commercial strains of ragi, *Eleucine coracana*, three from Mysore, and four from Coimbatore, have been examined for their malting characteristics. A complete laboratory equipment for experimental malting and kilning has been made and this has rendered possible the examination of a large number of specimens under standard experimental conditions. Suitable analytical standards for ragi malt have been fixed and from a physical and chemical examination of the ragi and the malt derived therefrom, it has been possible to evaluate its malting quality. Our

studies have revealed that H_{22}, the strain evolved by the Mysore Agricultural Department, meets most of the requirements of malting.

31. Nutritive value of *trichosantheusdiocea* (Parwar).

C. C. SHAH *and* B. M. PATEL, Baroda.

A full analysis of the vegetable has been made. This vegetable contains a high percentage of asn and prôteins. Its contents of carotene and vitamin C are also high. There is however no reason to believe that the high price of this vegetable is associated with any special nutritive constituents.

32. Future of cloves in India.

V. K. BADAMI, Cuttack.

At present Zanzibar and Dutch East Indies enjoy the monopoly of clove cultivation. A survey made by the I.C.A.R. shows that certain areas in Southern India, e.g. Travancore, Nilgiris and Mysore are suitable for its cultivation. Difficulties in raising seedlings and enormous casualties in newly-laid gardens have checked the extension of clove cultivation in India.

The writer published the results of certain experiments on the germination of clove seeds in 1938 as a bulletin of the Agricultural Department of Mysore. He had stated there the possibilities of grafting cloves on other *Eugenias.* The present paper deals with the grafting experiments conducted in Orissa in 1940.

During the Monsoon between May 15th and August 15th inarching of clove plants was made on several *Eugenias* when the temperature varied between 85°F. to 100°F. and the humidity between 85 to 90%. The seedlings of both the cloves and stock plants were hardly ¼ inch thick, and were placed in a well-lighted low-roofed thatched shed.

After inarching, the region of contact was protected by a bandage of clay and cowdung mixture. Gunny thread was used for binding. Within four weeks union of the two cambiums was complete. After October the shoot of the stock was removed and the severance was made gradually in the course of a month. Over a hundred grafts are now ready for planting.

The stocks that have given successful results are:—

Rose apple—Eugenia jambos, *Jam*—Eugenia jambolana, *Jamrul*—Eugenia alba (*E. javanica* Lamk.) and Eugenia aqua.

In Orissa *Jams* and Rose apples grow exceedingly well and they resemble the clove plant very much. As the Rose apple is a vigorous quick growing plant and withstands the rigors of the stiff soils, it has been used for grafting on a large scale. The indications of the experiments are that by grafting on Eugenias, suitable to the locality, the vagaries of soil conditions can be removed, and by attending to other requirements of clove, it can be successfully grown in several regions of India.

33. Bael as a source of hardy stock for oranges.

V. K. BADAMI, Cuttack.

In the stiff water-logged soils of the Mahanadi delta, oranges take a good start, give promising hopes but die out in large numbers just when they begin to bear. When the roots reach the stiff clay sub-soil the tragedy begins. Grafts are usually made on *jamberi* or sour orange stocks. Evidently the root systems of the stock plants cannot withstand the hard conditions.

Aegle marmelos (Bael) grows well on dry or stiff soils and seems to stand even water-logged condition for a long time. Cultivated forms

grow well even on the plains. Some of the fruits are of considerable size. Possibilities of utilizing bael as a stock plant were explored during the year and scores of successful grafts have been made.

A year old seedlings were used as stocks on which the oranges were inarched. Within three to four weeks, during May to August, the cambiums unite and the grafts are ready for separation. It is however, better to leave the grafts to harden till October and then sever them gradually. Both the *Santras* and Mosambic types can be easily grafted in this way.

It is now proposed to plant the bael seedlings in '*situ*' in the garden and to inarch the required variety on the seedlings during the monsoon. Scores of grafts are ready now for planting and their progress will be watched.

Plant Breeding, Genetics and Cytology

34. Inheritance of height of plants in *Sail* paddy.

H. K. NANDI *and* P. M. GANGULI, Jorhat (Assam).

The height of paddy plants is a genetical character although it is very much influenced by environmental conditions. The height has been found to vary from about 90 to 180 cm. in the 272 types of *Sail* paddy studied at the Karimganj Farm. Several crosses were tried between tall and dwarf types of paddy. In all of them tallness was found to be dominant over dwarfishness, except in the cross described in the paper, where a dominant dwarf type of paddy was involved with a simple monogenic segregation in F_2.

35. Variability in *Boro* paddy.

P. M. GANGULI *and* J. L. SEN, Habiganj (Assam).

Boro or spring paddy is one of the main crops of the low-lying areas in the Surma Valley, specially Sunamganj and North Habiganj. Along with deep water *Aman*, it covers almost the entire area under cultivation in these tracts. The paper summarizes the studies in spring paddy, classified on the basis of their important botanical characters. The variability in some of the quantitative characters, such as, length and breadth of paddy and rice, weight per 1,000 grains of paddy, height and the number of tillers per plant, flowering duration, length and number of grains per panicle and the sterility percentage of grains has been studied for each of the classes separately. The paper discusses the variations noticed between and within the classes for all these characters.

36. Intra-relationship of some plant characters with the yield of *Boro* paddy.

P. N. GANGULI *and* J. L. SEN, Habiganj (Assam).

The intra-relationship of the height of tillers, the length of panicle and the number of grains per panicle with the yield of *Boro* paddy was studied in the Rice Experiment Station, Habiganj (Assam). The following facts have emerged from this study:—

(1) The height of tillers, length of panicle and the number of grains per panicle in a pure line are individually and severally correlated with the yield. In every case the correlation coefficient is a positive one.

(2) The intra-relationships of the height of tillers and the number of grains per panicle with the yield are weaker than that of the length of panicle and the yield.

(3) For every unit increase in the height, length of panicle and the number of grains per panicle the yield increases by ·041, ·35 and ·022 respectively.

(4) For increasing the yield a unit increase in the length of panicle is more effective than a similar increase in the height of tillers or the number of grains per panicle. Again, a unit increase in height can raise the yield higher than a similar increase in the number of grains per panicle.

37. Inter-specific hybridization in *Oryza*.

C. R. Srinivasa Ayyangar, N. Parthasarathy, *and* K. Ramaswami, Coimbatore.

Hybridization of cultivated rice (*O. sativa*) with various wild species of *Oryza* was one of the items in the breeding programme of the Paddy Breeding Station, Coimbatore, for rice improvement work in the Madras Presidency. This paper deals with (1) the success obtained in the evolution of economic strains in the progenies of the cross (GEB. 24) *O. sativa* × *O. longistaminata*; (2) the building up of a tri-specific hybrid: *O. sativa* ($n = 12$) × *O. officinalis* ($n = 12$) × *O. eichingheri* ($n = 24$), based on the study of the meiosis of *O. sativa* × *O. officinalis*.

38. A new type of variegation in rice.

B. P. Pal *and* S. Ramanujam, New Delhi.

A new type of variegation is described. The variegated plants have fine stripes of green and white on the stem, foliage and glumes. They are weaker than the green plants with narrower leaves and poorer seed-setting.

The variegated plants when selfed give rise to variegated plants and albinos in varying proportions; but when crossed reciprocally with green plants, give rise to normal greens in the F_1 generation. Heterozygous green plants segregate into greens and variegates in the ratio of 3 : 1; no albinos are present in the progenies.

The breeding behaviour of variegated plants in selfed and crossed progenies has shown that variegation is a mendelian recessive to green but albinism is transmitted only maternally.

39. Some interesting features in a cross between a purple and a green coloured variety of paddy.

P. D. Dixit, Cuttack.

A cross was undertaken in 1937-38 with the object of evolving a white riced good quality paddy having a purple colour in vegetative and floral parts, as a help in the eradication of wild paddies. The purple parent was a type fixed from the variety Lenkapuri having red rice. The green parent from which pollen was taken was a selection from the variety Bayahunda with white rice. The F_1 plant was entirely purple as expected but the rice colour was white instead of red. The size of grain did not resemble either parent being shorter in length but broader than both the parents. The F_2 generation consisted of 203 plants. All the plants were completely purple like the purple parent and had white rice as that of the green parent. No plant with red rice appeared even in the F_2 generation. There was segregation in the size and colour of grain. F_3 generation is under study.

40. A sugary mutant in pearl millet (*Pennisetum typhoideum*).

Z. H. PATEL, Palitana.

In certain crosses in Pearl Millet, African variety, meant for the study of the inheritance of chlorophyll characters, a mutation occurred which had besides the ordinary starchy grain, another type with deeply wrinkled seeds appearing in the same earhead. The latter seeds were sweet to the taste and had endosperm with glassy structure. Actual counts of the two types of grains in the earhead gave 1,742 starchy to 825 sugary grain; when these were grown separately in the following year, all the sugary seeds bred true to the character and of the starchy grain some bred true to starchy while others segregated in the same way.

The plants from the sugary seeds give earheads slightly smaller than the normal and the seeds are about 80% of the weight of the normal starchy seed.

Further, breeding of the heterozygotes gave highly varying ratios between starchy to sugary seeds ranging between 1·4 : 1 to 3·12 : 1, and there was always an excess of the sugary grain beyond what a simple recessive should warrant. In certain other natural crosses where also this character was appearing, the sugary grain, unlike the above cross, was in defect. The general behaviour of the sugary mutation in this crop appears to resemble in all respects with a similar mutation in maize and has been designated by the symbol *su*.

41. A new gene affecting anthocyanin pigmentation in asiatic cottons.

K. RAMIAH *and* BHOLA NATH, Indore.

A new member of the R_2 series of alleles controlling anthocyanin pigmentation in asiatic cottons first observed in a South Indian type called *tellapathi* is reported. It resembles the R_2^{AS} allele in that the petal spot is present and differs from it in the absence of leaf spot and pigmentation in anther filaments. Pigmentation in the stem is much less than in the R_2^{AS} type, the pigment being suppressed altogether under certain conditions, but can easily be differentiated from *tellapathi* plants. The symbol R_2^{AS} is assigned to the new allelomorph.

The relationship between plant-body pigmentation and petal spot is discussed and evidence is presented to show that there is no crossing-over between the two and they are therefore controlled by components of the same gene.

42. Further studies on the Punjab hairy lintless gene in cotton.

K. RAMIAH *and* P. D. GADKARI, Indore.

Extensive studies on the homozygous lintless type during the last three years have shown that there is considerable variation in the effect of the gene on its viability under different environmental conditions. The effects of the gene on the component parts of the leaf that control the leaf shape are such as to disturb normal segregation for the leaf shape character. The gene also affects the growth of the plant according as it is present in the heterozygous or homozygous condition.

43. Cytological investigations in *raya* (*Brassica juncea*, Coss), *toria* (*Brassica napus* L. *var. dichotoma*, Prain) and F_1 hybrid between them.

ALI MOHAMMAD *and* SAWAN MAL SIKKA, Lyallpur.

The paper deals with the cytology of two species of Brassica, namely *B. juncea*, Coss (*raya*) and *B. napus* L. *var. dichotoma*, Prain (*toria*) and the F_1 hybrid between them. *Raya* has $2n = 36$ chromosomes, which during meiosis synapse into 18_{11} in large majority of P.M.C's. *Toria* has $2n = 20$ chromosomes, which invariably form 10_{11} at diakinesis and metaphase I. With the exception of a few irregularities observed in *raya*, the whole course of meiosis in both the parental species is quite normal. The F_1 hybrid has $2n = 28$ chromosomes, conjugating into $10_{11}+8_1$ according to the *Drosera* scheme. Evidence is adduced to show that the ten bivalents in the hybrid are formed allo-syndetically. The bivalent chromosomes of the hybrid behave normally during the whole course of meiosis, but the behaviour of univalents is erratic, resulting in the formation of gametes with hypo-diploid to diploid number of chromosomes. The hybrid produced only 10 per cent good pollen and formed but few pods and seeds. It is suggested that the functioning of the un-reduced gametes may result in amphidiploids in the F_2 progeny of the cross, some of which may be of greater economic value than the existing forms of Brassica.

Crop Physiology

44. A preliminary study on vernalization in rice.

S. HEDAYETULLAH *and* N. K. SEN, Dacca.

A highland *Aus* variety, Dhairal was germinated with 55–60% water per dry wt. at 29·5°C. and the seeds were exposed to the following temperatures 0°C. ± 1°C. (V_1; V_2), 11°C. ± 1·5°C. (V_3; V_4) and 29·5°C. ± 1·5°C. (V_5; V_6) for 15 and 10 days respectively making 6 treatments in all. Seeds of the 6 treatments were sown with a control set, C., in earthenware pots. Weekly records of tillers, height, and the number of the topmost mature leaf were taken for each plant. The results are recorded below.

Rate of ear emergence: V_5; V_6; $\overline{/V_3;}$ $\overline{\underline{/V_2; V_4;/}}$ $\overline{V_1; C./}$

Av. no. of ears: V_5; $\overline{/V_6; C./}$ $\overline{\underline{/V_3; V_4; V_2; V_1/}}$

Dry of wt. of grain: $\overline{/V_5; V_6; C.;/}$ $\overline{/V_1; V_2; V_3; V_4/}$

45. Influence of soil drought on growth of wheat.

I. M. RAO, M. AFZAL, *and* J. C. LUTHRA, Rohtak.

The effect of soil drought of different durations and intensities on the injury caused and the possible recovery (when restored to normal conditions) as measured by the changes in the rate of growth of wheat was studied in pot cultures.

In the first season wheat 8A was grown with good moisture supply up to 15 weeks. After stopping watering for one week in one set and two weeks in another it was resumed. The rate of growth was affected adversely both during and after the drought of long duration. Smaller shoots suffered more.

Reduction of soil moisture to different levels (10%, 8%, 6% and 5%) for two weeks during the vegetative period of wheat 8A (a 'late' type) and 9D (a 'medium' type) resulted in a relative decrease in the rate of growth of the main shoots but below 8% (4% above the wilting coefficient), growth stopped in both the types. The recovery was proportional to the

intensity of the drought. The types did not differ, apparently due to the difference in their growth periods.

A similar study, conducted with wheat 9D and C. 591 (both medium types) indicated that recovery in C. 591 was comparatively less than in 9D. Yield of grain of both the types was proportional to the intensity of the drought experienced but C. 591 suffered more than 9D which consistently gave higher yields even under field conditions.

It is possible to distinguish between drought resistant and susceptible strains by similar quantitative studies under controlled conditions.

46. Stomatal studies in 'rabi' (winter) crops grown under dry farming conditions.

I. M. Rao, M. Afzal, *and* J. C. Luthra, Rohtak.

Following Lloyd's technique for fixing epidermal peels, the relationship between stomatal characters and 'drought resistance' was studied in detail in wheat types (9D, Cwn. 13, C. 591, 8A and C. 518), barley, Taramira (*Eruca sativa*) and Sarson (*Brassica campestris*) when grown under dry farming conditions. The two oil-seed crops are known for their 'drought resistance' compared to wheat and barley. Among the wheat types, 9D and Cwn. 13 are better than the others.

Taramira and Sarson had a larger number of smaller stomata and epidermal cells, more stomatal linear units per unit area and a higher stomatal index than wheat and barley.

Among wheat and barley, the difference was slightly in favour of wheat. The values were higher in wheat 9D and Cwn. 13 than in the other wheats. Irrigating the above wheat types resulted in a lowering of the above values. In wheat the distance between the ends of two stomata in a row was much less than ten times the length of the stoma which is the minimum spacing according to Brown and Escombe for optimum gas diffusion without any interference.

The appearance of constrictions at either end during partial closure of a stoma in cereals resulting in three pores, a central bigger one and two lateral smaller ones, is interesting.

Higher values for stomatal frequency, number of epidermal cells, stomatal index and stomatal linear constant are characteristic of xeromorphism and should help in selecting strains of crops for dry areas.

47. Investigation on the causes of and remedial measures for the 'red-leaf' disease of cotton in Sind.

T. J. Malkani, Sakrand.

The increasing severity of the red-leaf disease of the Sind American Cottons with the consequent adverse effect on the yield has led to a detailed investigation of this problem. Two distinct types of red-leaf disease have been observed in Sind. These have been described; one appears to be due to insect attack while the other has been found to be due to physiological disturbances in the plant and lack of nutrition in the soil. It is the latter type that is mainly dealt with in this paper.

It has been ascertained that this type of red-leaf disease occurs in the same spots year after year irrespective of variety, sowing dates and irrigation and the plants develop the same symptoms in sandy areas which are, as a rule, deficient in plant food material.

From detailed growth observations and analysis of soil and plant it has been found that the disease is due to deficiency of nitrate nitrogen in soil and that it can be counteracted by treating the soil with easily available nitrogen in the form of an artificial fertilizer.

48. Experiments on shortening the rest period of potato tubers in the Punjab.

J. C. LUTHRA *and* GHIAS-UD-DIN AHMAD, Lyallpur.

For autumn sowing in the Punjab plains, seed-potatoes are obtained from other provinces at a high price. The seed-potatoes obtained from the spring crop in May and June, if stored in hills, form a useful supply for autumn sowing.

In the Kangra District on higher altitudes potatoes are dug out in September. Experiments were carried out to investigate the effectiveness of some chemicals under the hot Punjab conditions to break the dormancy of Kangra Local *Desi* potatoes thus making them fit for autumn sowing in the plains.

The ethylene chlorhydrin dip treatment for whole tubers and sown either as such or cut gave the most encouraging results. The potency of the solution seemed to decrease with its consecutive uses.

Potassium thiocyanate and thiourea also showed favourable results as compared to the control but these were distinctly inferior to the chlorhydrin.

More than one bud sprouted in the case of the treated lots and the growth of the plant was very luxuriant. The quality of potatoes harvested from the chemically treated sets was very satisfactory both as regards taste and size. More work is needed to confirm the effect of these chemicals on the yield.

49. Inducing germination in fresh potatoes.

V. K. BADAMI, Cuttack.

Extension of potato cultivation in Orissa is creating an acute situation in the economy of the cultivators' budget. At the time of harvest, potato is sold at Rs.2/- a maund but the cost of seed tubers at the time of planting goes up, between Rs.16 to Rs.20 per maund. The high summer temperature of Orissa is not conducive to preserve seed tubers. Often the rotting is more than 70%. Continuous cropping throughout the year and preserving the seed tuber at higher altitudes available, have not been quite successful. An additional difficulty lies in the poor germination of freshly dug potatoes without a dormancy period.

Ethylene chloro-hydrin used in Canada has been used with some success. Soaking entire tubers gave poor results of 7% germination. Cut tubers soaked in 0·4% solution of ethylene chloro hydrin gave good germination of 84·5%. Using the same solution a second time gave only 47% germination. Third immersion gave 6% and the fourth one only 2% germination. Soaking in water alone as check gave about 6% germination.

Since mere water alone gave some results, a series of tests were made with water. Over 90% germination was obtained with the following method. Cut tubers were first steeped in water and at the end of every hour the pieces were washed and put in fresh water and the process repeated three times. Then the washed tubers were spread on a damp gunny cloth and covered over with another damp gunny cloth. In 24 to 36 hours sufficient cork formation takes place to protect the cut surfaces. Such treated pieces planted in sand and watered begin to germinate in 6 to 10 days time.

Planting immediately without allowing time for cork formation is very dangerous, as over 95% of them rot. Fields planted with new potatoes treated in this way have produced healthy plants. In November when the fresh crop is available from the hills the adoption of the above would greatly reduce the cost of seed potatoes by nearly half and help the potato cultivator to cut down cost of production.

50. Effect of indole-butyric and three other acids on rooting of *litchi* cuttings.

P. K. Sen, Sabour.

A series of experiments using indole-butyric, indole-acetic, phenyl-acetic and naphthyl-acetic acids indicated that (1) cuttings of the *litchi* can be rooted to the extent of 100 p.c. by treating two-year wood cuttings with 50 to 100 milligrams of indole-butyric acid per litre for about 24 hours; (2) a stronger solution or the same solution treated for a longer period has a relatively retarding effect; (3) one-year wood cuttings show a lesser response but current-year wood with or without leaf and/or tip cannot initiate callus formation or rooting; (4) the period between June and September, i.e.. when the *litchi gootee* is normally prepared, is the best season for making cuttings; (5) abundant callus formation does not always give rooting.

51. Chemical stimulation to cotton growth.

A. Sreenivasan, Indore.

Replicated small plot trials were carried out to ascertain whether the hormone β-indolyl acetic acid (B.D.H., dilution 1 in 20,000) was likely to stimulate cotton growth in the field when the seed was treated before sowing with the chemical in different ways. The seeds soaked overnight either in plain water or in the solution of the hormone were given a coating in the usual way with a mixture of soil and dung impregnated in one case with the chemical. The coated seeds were then sown by dibbling. Half the plots were also treated with the hormone which was impregnated in a small quantity of screened compost. The other plots were treated with similar quantities of compost alone.

Soaking in plain water gave higher yields compared to soaking in the chemical. In the former case, the yield was lower when the coating material contained the hormone. Besides, the yields in plots treated with compost impregnated with the hormone were lower than in the corresponding plots without the hormone. These differences may be due to the fact that the dung used for coating the seeds itself contains an activator and therefore the concentration of the hormone used has been toxic. Further investigation with varying doses of the hormone is necessary before it can be stated whether or not the hormone can be successfully used to stimulate cotton growth.

Plant Diseases

52. The *Myitpo* disease of paddy.

Ashutosh Sen, Mandalay.

A serious disease of paddy called *Myitpo* (in Burmese) occurs in one of the irrigated tracts of the dry zone area in Burma (Shwebo District). Large patches ranging in size from 30 to 100 ft. or more in diameter are formed. The plant becomes stunted in growth sometime after transplantation, turns yellow and withering and drying of leaves follow. Eventually the whole plant dies. In pot experiments with soils from two *Myitpo* affected areas considerable responses have been obtained to the application of soluble phosphate and particularly to phosphate and nitrogen given together.

In field experiments, full confirmation of the above results has been obtained. Furthermore, the application of niciphos is found to cure the disease. Since nitrogen alone has practically no effect in the most affected area, the fertilizer should have a wide instead of a narrow N : P

ratio. Pure dicalcium phosphate gives no response. A few trace elements B, Mn, Zn, Co, Al, Fe, As, Sb, Ag, Cd, F, Sn and Sr also give no response. Spectrographic analysis reveals no difference in the presence of minor elements between the *Myitpo* affected and the adjacent normal plants or soil. There is a considerable accumulation of P_2O_5 in the root of the affected plant at the time the disease sets in indicating thereby that the affected plant is able to obtain sufficient P_2O_5 from the soil for its requirements but it is unable to utilize it. In the light of the above results and from the general experience of the cultivators in the area that *Myitpo* does not occur in the same field every year and that early and fair distribution of rainfall tends to prevent the disease, it is suggested that *Myitpo* is probably caused by a biological agent which is effectively controlled by the application of a soluble phosphatic manure.

53. The wilt disease of coriander (*Coriandrum sativum*) in the Gwalior State.

G. S. KULKARNI, Gwalior.

The coriander crop in the Gwalior State, especially in the Guna District suffers from a severe attack of Wilt disease. The destruction caused by the disease is at times so great as to wipe out the crop completely. Losses amounting to 50 to 60% are very common. In money value the total annual losses amount to more than five lacs of rupees.

The causal organism examined in the majority of infected plants has been found to be a Fusarium though occasionally a Rhizoctonia is also met with. The disease is not found in other crops that are usually grown in the tract, viz., maize, jowar, wheat, peas, lentil, methi and rajagira.

The disease is being studied with regard to the pathogenicity of the fungus and various environmental conditions, such as temperature, humidity, time of sowing the crop, etc. Control measures with a view to evolving resistant types are also in progress. In the previous season 90 selections have been made. These, together with the samples of seed obtained from Lyallpur, Dharwar, Coimbatore, Khatmandu and Mandale will be sown and their progenies tested for resistance.

54. Transmission of vinca spike to Santalum album Linn. and its significance.

Y. MUNIYAPPA, K. SUBRAMANYAM, *and* M. SREENIVASAYA, Bangalore.

The problem of the primary sources of infection of spike disease has so far remained obscure and the long distance flights which characterize the spread of spike have not been adequately explained. It has long been suspected that agricultural and forest hosts affected by similar diseases may constitute the primary sources of infection and striking evidence to this suspicion was afforded by the observation that every site of primary attack by sandal spike was associated with the prevalence of similar diseases among the neighbouring agricultural and forest stands. It was therefore of interest to study the inter-transmissibility of the two groups of diseases—the spike of sandal and the 'spikes' of other ecologically associated hosts of sandal. We have now been able to demonstrate the transmissibility of 'spike' affecting *Vinca alba* to sandal.

Diseased leaf tissue from Vinca has been grafted to potted six months old sandal plants by the 'leaf insertion' technique so successfully employed in all our previous transmission studies. After eight to ten weeks the sandal developed typical symptoms of a virulent form of spike. For the first time, the possibility of other 'spikes' acting as equally virulent and potential foci of infection, has now been demonstrated. In the

eradication of the sources of infection which is now widely adopted as the only effective method of controlling spike disease, careful attention should be paid to the other sources of 'spike'.

55. Proteoclastases in healthy and spiked leaves of Santalum album Linn.

K. SUBRAMANYAM *and* M. SREENIVASAYA, Bangalore.

An accumulation of total organic nitrogen (two to three fold) takes place in the diseased leaves and this is accompanied by an increase in proteoclastic activity. The inorganic forms of nitrogen, nitrate and nitrite, present in healthy leaves have been found to be absent in the diseased leaves, thus pointing to a fundamentally different type of nitrogen metabolism characterizing the diseased condition.

It was therefore of interest to make a comparative study of the nature of the proteoclases present in the healthy and diseased leaves. Experiments in this direction have revealed the presence of a higher concentration (2-3 times) of a cyanide activable proteoclastase capable of hydrolyzing peptone. This enzyme is inactivated in presence of oxidases.

Enzyme preparations from healthy and diseased leaves made by different methods exhibit consistent and characteristic differences.

The higher peptonase activity of the diseased tissues and tissue fluids accounts for the presence of amino nitrogen in a higher concentration.

Statistics and Sampling Technique

56. The use of *d*-test in the comparison of two samples with unequal variance.

P. V. SUKHATME, New Delhi.

The quantity d, defined as the quotient of the difference in two means by the square root of the sum of the variance of the two means, was originally proposed by Behrens (1929) as the solution of the hypothesis that the difference in two population means is zero. Fisher (1936) using fiducial argument in statistical inference showed that the distribution of d supplied the exact solution of the hypothesis. Bartlett (1937) was doubtful of its validity. Sukhatme (1938) gave tables of d and showed that Behrens was wrong in his assumption regarding the behaviour of the fiducial probability of d with θ. Fisher (1939), using Sukhatme's work, clarified Bartlett's doubts and produced further independent evidence to prove the validity of the d-test.

The use of the d-test in experimental work and the hypothesis of which it supplies the exact test have been explained on two examples from agriculture. The differences between the t and the d tests have been emphasized and special attention is drawn to the difference in the interpretation that is made by the use of t test in place of d.

Five per cent tables of d for the framework 6, 8, 10, 12, 24 and ∞ and $\theta = 0°$, 15°, 30°, 45°, 60°, 75°, 90° have been supplied and their use explained.

57. Incomplete double Latin squares.

P. V. KRISHNA IYER, New Delhi.

The analysis of a $p \times p$ double Latin square layout in which row or columns are missing from either one or both the squares, reduces to a neat form in certain cases. Changes in the usual procedure of analysis are necessary in the calculation of the treatment sum of squares, the

treatment means and the standard error for comparing two treatment differences. The sum of squares for squares, rows and columns are calculated in the usual way. The expressions for the treatment sum of squares, the least square estimates of the treatments and the standard error for comparing two least squares estimates are given in the paper for the following cases:—

(i) First square—one row missing: second square—complete.
(ii) Both squares—one row missing.
(iii) First square—one row and one column missing; second square—one row missing.
(iv) First square—one row and one column missing; second square—complete.

58. Comparison of different sampling techniques for population studies on wheat.

I. M. RAO, M. AFZAL, *and* J. C. LUTHRA, Rohtak.

Under Dry Farming conditions in the Punjab, variations in growth and other characters are high due to soil heterogeneity and drought conditions. A preliminary study was carried out on wheat during *rabi* 1939-40 to compare the sampling techniques, recommended by Hudson, Kalamkar and the Dry Farming Committee, India.

Observations on germination, stand, tillering and maturity at the final stage were noted on wheat 8A sown in a plot of about one-seventh acre with 40 rows, each 122 feet long, divided into 16 sub-plots, each five rows 61 feet long. Two levels (5% and 10%) were adopted for the fraction of area sampled. The units were randomized in each sub-plot separately.

The sampling errors, calculated according to the formula s :

were converted to percentages on the general mean for the whole plot.

The sampling errors for all the techniques were in general low. They were below 5% for all observations except for 'germination' (about 6%) and mature ears (about 10%). Kalamkar's technique gave the lowest sampling error apparently due to the greater distribution of the units. The difference due to the techniques was not high. Increase in the area sampled resulted only in a slight lowering of the error. Under local conditions, the Dry Farming Committee method of sampling seems to be as good as that of Hudson. Kalamkar's technique involves great labour and results only in a slight lowering of the error.

Marketing, Agricultural Economics

59. A note on the grading of grape, papaya and grape-fruit.

S. S. BHAT *and* S. R. DHARESHWAR, Baroda.

In this note the external and internal characters to be taken into consideration while grading fruits are mentioned. The size factors of Bhokari grape, Washington papaya and Marsh seedless grape fruit are studied in detail. In Bhokari grapes, it is noted that while the weight of the berries varies from 1·5 to 5 gms. each, there is a tendency for berries in smaller bunches to be larger than those in larger bunches; the size and weight of individual bunches vary from about 2 ozs. to 20 ozs. and more. In the case of the Washington papaya, the fruits vary in weight from below 30 ozs. up to 100 ozs. or more with a mean value of 53 ozs. Their length, circumference and weight (on 786 individuals) are found to be positively correlated. In the Marsh seedless grape

fruit also all these size factors are found to be positively correlated (on 990 individuals). In order to facilitate grading work, the authors suggest that Bhokari grape bunches and Washington papaya fruits may be graded on the basis of their weight while the Marsh seedless grape fruits may be graded by their circumference. The authors propose that the market value of graded fruits affected by surface blemishes may be reduced according to the formula

$$\frac{\text{Total percentage of blemishes} - 5\ \text{(allowable percentage)}}{2}.$$

60. The economics and agricultural problems of the sugar industry in India.

B. MUKHERJEE, Lucknow.

The paper discusses the present position of the industry in India in all its aspects, more particularly with reference to such problems like over production, minimum price, uncontrolled extension of cultivation, export markets, consumption of sugar within the country, improvement of the *Khandsari* system, cane varieties and the economics of cultivation, control of pests attacking the crop, etc. The author concludes by drawing attention to the importance of further research and greater utilization of the bye-products of the industry.

61. Working of seed agencies of the Punjab Agricultural Department.

K. S. HAFIZ MOHD. ABDULLAH *and* NEK ALAM, Punjab.

The paper discusses the development of the seed agencies in the Punjab. The seed distribution agency which was first confined to government farms was later decentralized by the setting up of a large number of seed producing centres on cultivators' land. The number of such agencies has multiplied rapidly, from 317 in 1933 to 1103 in 1939, with a gross expenditure of 12 lakhs of rupees in 1939.

Certain details with regard to the working of sixty-eight such seed agencies of seven different teshils have been collected to give information on (1) the average quantity of seed purchased by each zamindar, (2) the frequency with which the zamindars go to the agencies for purchasing seed, (3) comparison of agencies located in urban or rural areas, (4) the effective distance up to which an agency can cater, etc., and those are recorded in the paper. Based on the above information the authors conclude that a radius of five miles would form an effective distance for each agency and that the agencies should be shifted from village to village after every 3–5 years.

62. An enquiry into the sale and use of improved agricultural implements in the Punjab.

K. S. HAFIZ MOHD. ABDULLAH *and* NEK ALAM, Punjab.

The authors have first examined the information contained in the annual reports of the Agricultural Department with regard to the sale of implements during the last eight years and found that the number of chaff cutters, ploughs, hoes, harrows and drills per 100 pairs of working cattle are 6·9, 2·1, 0·15, 0·10 and 0·09 respectively. They have made a detailed survey in 450 villages comprising 15,000 zamindars of Gurudaspur, Amritsar, Rawalpindi and Jhelum districts taking 15 to 20 villages at random for each teshil and ascertained the number of improved imple-

ments possessed by the zamindars which were found to vary with the tract surveyed. Some interesting data are furnished showing the relation between the number of implements owned and such factors as: (1) the distance of the village from the teshil headquarters, a main road or a railway station, (2) the size of the village, (3) the caste of the zamindar and (4) the literacy or otherwise of the zamindar.

63. The economics of goat and sheep herds in Pind Dadan Khan Teshil of the Punjab.

K. S. HAFIZ MOHD. ABDULLAH, NEK ALAM, *and* M. MOHD. FAZIL, Punjab.

The paper deals with the information obtained from enquiries made in the locality of twenty-eight herdsmen who maintain flocks of both sheep and goats. The data discussed separately for sheep and goats deal with such aspects as the average birth rate, the percentage of males and females, the percentage of animals disposed of every year, the percentage of mortality among animals, the sale price of animals, the quantity of wool obtained, the price of wool and how it is disposed of, etc.

64. The milk and ghee supply of nineteen villages of Rawalpindi Teshil, Punjab.

K. S. HAFIZ MOHD. ABDULLAH, NEK ALAM, GHULAM RASUL, *and* HAYAT MOHAMMAD, Punjab.

The authors have studied the milk and ghee supply of nineteen villages of Rawalpindi teshil comprising 605 families of 3,497 members. Information is given regarding the amount of milk produced, how much of it is actually consumed and in what form, how much of it is sold and how much is converted into ghee. The authors conclude that as regards milk consumption the villages in this teshil do not compare favourably with cities and that the accepted idea that villagers consume more milk is not true. The consumption of milk per head per day comes to only 0·07 lb. as against 0·25 in Lahore and 0·54 in Lyallpur.

General

65. A new method of recording phenological observations.

F. R. BHARUCHA, Bombay.

Systematic recording of some forty plants, varying from trees to shrubs, was done over a year. There are many methods in vogue, for example, the one used by the Royal Meteorological Society of London, another by Illechevsky in Russia and still another in America. Each is devised from a different standpoint. A simpler method than the previous ones has been devised by the author and described in the present paper giving the actual observations made over a year.

66. Effect of synthetic fertilizers on grasslands.

F. R. BHARUCHA *and* R. N. DAVÉ, Bombay.

So far no attempt has been made in India to employ synthetic fertilizers for increased yield on grasslands though it is now an established fact that larger powers lie latent in grassland than in aerable land. Three years' repeated experiments carried out by the authors on different types of grasslands, i.e. differing in the intensity of pasturing, have

shown: (1) that the use of synthetic fertilizers improves the grasslands provided the fertilizers are of the right type and the intensity of pasturing has not exceeded a certain limit; (2) superphosphate alone in top dressing is sufficient to yield higher results on an area where the grasses are pastured only for two months of the year; (3) ammonium sulphate and superphosphate should be combined on an area where pasturing has been sufficiently severe; (4) potassium sulphate is not effective at all, and (5) on a totally over-pastured area where the dominant grass is not *Themeda* or *Pseudenthistiria* (grasses which are dominant singly or jointly on moderately or slightly grazed areas) but *Egrafrostis uniloides* with a very high percentage of weeds like *Blumea eriantha*, the application of a mixture of the above three manures has no effect.

SECTION OF PHYSIOLOGY

President :—B. B. DIKSHIT, M.B.B.S., M.R.C.P., D.P.H., PH.D.

General Physiology

1. Acetylcholine formation by the intestines.

B. B. DIKSHIT, Bombay.

Formation of acetylcholine by the intestines when small bits are suspended in oxygenated Ringer's solution containing eserine has been previously demonstrated by several workers. The present communication is concerned with acetylcholine formation by intestines when perfused through the superior mesenteric artery. The technique of perfusion consisted in perfusing the small intestines with warm, eserinized, oxygenated, Locke's solution through the superior mesenteric artery and passing the same solution over and over again through the vessels for a period of over five hours. The amount of acetylcholine formed was measured biologically using the frog's rectus abdominis as the test muscle. Guinea-pig, cat and dog's intestines were used and the amount of acetylcholine formed was found to be $3{\cdot}0\gamma$, $1{\cdot}5\gamma$ and $1{\cdot}0\gamma$ per gramme respectively. The perfused guts could further form acetylcholine when small pieces were allowed to respire in a warm oxygenated, eserinized Locke's solution.

2. Studies in vital capacity. I. Statistical correlation with physical measurements.

D. M. TELANG *and* G. A. BHAGWAT, Bombay.

The vital capacity of one hundred and seventy-two male medical students of Bombay—age range 18 to 29—has been statistically correlated with age, standing height, sitting height, weight, surface area (calculated from Dubois's monogram), chest measurements (deflated, inflated and the mean of the two), chest expansion and the pelidisi (Von Pirquet index). A significant correlation has been found with every one of the measurements except with age and pelidisi. Prediction lines of vital capacity against all these measurements (except age and pelidisi) have been plotted and the regression equations worked out in each case.

3. Vital capacity in healthy young Indians (U.P.).

S. N. MATHUR, Lucknow.

Average Vital Capacity, taken on the basis of over eleven hundred readings in healthy young medical undergraduates of ages between 20 and 25 was found to be about 3,200 c.c. This is about 10% less than the western standard.

4. Note on venous return.

W. BURRIDGE, Lucknow.

A solution of adrenaline poured over the viscera of a frog restores venous return after the ventricle has ceased to beat and is bloodless. It is presumed that this blood was previously stagnating in veins.

After blood had thus been returned to the heart its activity revived and it beat well again.

5. Prothrombin time in health and disease.

D. V. S. REDDY *and* C. VENKATARAMIAH, Vizagapatam.

Dam's investigations on chicks suffering from haemorrhages lead to the discovery of a new vitamin, Vit-K (so called because in German languages, it is spelt as Koagulation Vitamin). Simultaneously, Quick developed a simple but a specific method for the determination of blood prothrombin.

These two advances in basic sciences were soon followed by many animal experiments, throwing light on the factors and conditions producing hypoprothrombinemia. The knowledge gained thus found immediate use in the explanation and control of the haemorrhagic conditions, particularly, in jaundice and haemorrhagic diseases of the new born. Of all the methods, for the estimation of prothrombin both as laboratory diagnostic procedure and as guide to treatment, Quick's method or one of its modifications, may be conveniently employed in any ordinary teaching institution.

No investigations on prothrombin levels in Indians and in various clinical conditions in the tropics, have been published. According to Quick's technique, observations were made on 'prothrombin time' in twenty normal healthy adults, at Vizag. It was ranging between 40 and 50 seconds. The causes of this variation from the original figures given by Quick and the later observations of other workers are discussed.

Examination of cases of jaundice and cirrhosis of the liver revealed a definite and marked prolongation of prothrombin time. The effect of chloroform anaesthesia, dietetic deficiencies, and infections on the prothrombin time is being investigated.

6. Brain potentials of normal and deaf and dumb children and certain clinical cases.

BASU KUMAR BAGCHI, Calcutta.

In order to discover evidences of the growing maturation of the central nervous system on the one hand, and a possible change in its mass or local function due to lack of one sense organ and the presence of some abnormal conditions on the other, the electroencephalographic technique was used to record through un-opened skull spontaneously oscillating potentials of different parts of the brain of normal and deaf and dumb children and patients with a definite clinical history. The apparatus, only one of its kind in this country, consisted of a special four-stage push-pull high amplification amplifier and a recorder with a time constant of ·5 second delivering frequencies from $\frac{1}{2}$ to 50 per second. The subjects were comfortably placed in a cool, semi-sound proof, electro statically shielded room. It was found that usually the frequency of the brain rhythm per second increases with age until the adult alpha frequency is well established at about 10 or 11, that the alpha, slow and beta frequencies are mixed at and before that age, that deaf and dumb children present certain similarities and deviations and that the occasional slow rhythm in adults indicates cortical malfunctioning. Detailed results will be presented and implications discussed. Acknowledgment is due to Rai Sahib Principal A. C. Chatterji of Calcutta Deaf and Dumb School.

Biochemistry

7. The blood fat content of normal females living in Bengal.

HEMENDRANATH CHATTERJEE *and* SURATHNATH GHOSH, Calcutta.

The fat content of the blood of 20 normal non-pregnant females living in Bengal was estimated and was found to give an average value of 0·305 grm. per 100 c.c. of blood.

8. Studies on the anti-anaemic concentrate prepared from Indian ox liver. Part I.

S. K. GANGULY *and* U. P. BASU, Baranagore (Calcutta).

Several investigations have already been carried out in finding out the active principles from liver that might be effective in the treatment of certain primary anaemias. But as the efficacy of any concentrate depends upon the various entities (Murphy, *Amer. Jour. Med. Sci.*, 1936, **191**, 597; Karrer, *et al*, *Helv. Chim. Acta.*, 1938, **21**, 314 and others), any such work with liver demands a systematic investigation on the chemical characteristics of, as well as, on the actual reticulocyte response from the concentrate that might be isolated from glands of animals bred and slaughtered in tropical countries (*cf.*, Basu, *et al*, *Indian Med. Gaz.*, 1940, **75**, 215).

In the present work Cohn's fraction 'G' was prepared in different ways and at the various temperatures. The total yield, the percentage of nitrogen in the solid extract, its amino (Van Slyke) nitrogen, and certain characteristics of the portion soluble in 70% alcohol, but insoluble in 90% alcohol were determined. The amount of reinecke salts and the intensity of colour imparted by their solutions were again ascertained to have a rough estimate on the physiological active substances that might be present. Further work to find out the exact chemical nature of the active principles as well as their effect on reticulocytes on clinical application are in progress.

9. Mineral constituents of human hair.

K. N. BAGCHI *and* H. D. GANGULY, Calcutta.

In connection with an investigation about the lead-content of human tissues it was discovered that hair is very rich in lead. It was thought that other metals might also be present in hair in large quantities and with this idea in view the samples of hair were examined for the various metals likely to be present. The determination of Cu, Zn, Co, Ni, etc. in hair was made and they were found in appreciable amounts.

Boyd and De (1933) showed by spectrographic method that elements such as silver, tin, rubidium and vanadium and other common metals are present in human tissues while nickel and cobalt are absent. We could find appreciable amounts of Ni and Co but could not detect Ag, Sn, Rb and V in hair.

As the normal mineral-content of hair appears to be many times more than that of tissues, the analysis of hair gives a correct indication of all the elements present in human tissues and a careful investigation in this direction is likely to give an idea of the actual amount of these elements and their physiological significance. The investigation is in progress.

10. Blood urea clearance in normal Indians.

S. K. GOKHALE, Bombay.

Möller, McIntosh and Van Slyke (*J. Clin. Invest.*, 1929, VI, 427) had shown that blood urea clearance affords the best means to determine

the efficiency of renal function. They have expressed it as a relation between urea in blood (B), urea in urine (U), and the volume of urine excreted per minute (V) by means of a formula. The average clearance values obtained by them in their study of normal American subjects were 75 c.c. (maximum clearance $\frac{UV}{B}$, when V is $>$ 2 c.c.) and 54 c.c. (standard clearance, $\frac{U\sqrt{V}}{B}$, when V is $<$ 2 c.c.).

It was observed, in the study of blood and urine of normal Indian subjects, that while their blood urea content is within the same limits as that of American normal subjects, the urinary urea content, on the other hand, is about half of that of American subjects. In view of this, it was thought necessary to investigate whether the blood urea clearance value for average American adult will also hold good for average Indian adult.

Blood urea clearance values of 108 normal young Indians, have been determined by the same technique as described by the above authors. The average values obtained for Indians, 44 c.c. for maximum clearance and 34 c.c. for standard clearance, are much lower than the corresponding averages for Americans, viz. 75 c.c. and 54 c.c. respectively. This shows that the use of American averages to evaluate the renal function in the case of Indians would lead to erroneous conclusions.

11. Carotene contents of cow-ghee and buffalo-ghee.

K. N. BAGCHI *and* S. M. DAS-GUPTA, Calcutta.

The carotene contents of cow-ghee have been previously determined and it has been found that except under special circumstances, the value ranges from four to nine yellow units (Lovibond) per gramme of the fat. In this paper, the carotene contents of 30 samples of genuine buffalo. ghee from individual buffalos and herds (obtained from reliable sources) have been determined. The value ranges from 0–0·15 yellow units per gramme. We have not so far obtained a single genuine sample of buffalo-ghee having a carotene content higher than 0·2 yellow unit (Lovibond) per gramme.

The determinations were carried out in the following way:—The fat was melted and filtered through cotton and the colour was matched in one c.m. tubes in a comperator against a freshly prepared solution of potassium dichromate previously standardized with Lovibond Tintometer by Ratchevsky's method (*Bull. Soc. Chim. Biol.*, **17**: 1187–93, 1935).

The well-marked difference between the carotene contents of cow-ghee and buffalo-ghee may be helpful in differentiating cow-ghee from buffalo-ghee and thus in detecting fraud under the Food Adulteration Act.

12. Occupational factor in night blindness.

S. K. SEN, Calcutta.

A study has been made of a large number of cases of night blindness in persons working in the lime factories and brick kilns in the district of Howrah. Analysis of the foodstuffs shows vitamin A deficiency, but administration of cod liver oil, although has brought about an amelioration of the condition in some, has failed to effect a complete cure in many. In the laboratory, frogs and white rats have been given vitamin A deficient food and the visual purple extracted by digitonin method, and comparison has been made between the regeneration curves of the visual purple for the normal and vitamin A deficient animals. The effect of the exposure to brick and lime dust for some days, with subsequent administration of cod liver oil has been noted. In conclusion, it may be said that too much

exposure to irritating suspended matter in the atmosphere in which the persons are working is a potent factor in the causation of the disease, and acts synergically with vitamin A deficiency in the food and unhealthy surroundings of these individuals.

13. The effect of ingestion of large doses of vitamin C on clinical signs and symptoms and haematological changes in pulmonary tuberculosis.

S. K. Roy *and* M. N. Rudra, Patna.

The effect of oral administration, for 10 weeks, of 225 mgs. of natural vitamin C (as sundried Emblica officinalis powder) to Pulmonary Tuberculosis patients upon their clinical signs and symptoms and on haematological changes has been studied in relation to controls (P.T. patients) receiving no additional vitamin C. Greater improvement in total R.B.C. and W.B.C. Counts, haemoglobin content of blood, neutrophilelymphocyte and lymphocyte-monocyte ratios, von Bonsdroff's Count and Houghton's Index and a comparatively smaller improvement in sedimentation rate was observed in cases receiving additional vitamin C. Clinically also patients receiving additional vitamin C showed better results. The therapeutic value of vitamin C in Pulmonary Tuberculosis has been discussed.

14. The intradermal test as an index of vitamin C-nutrition.

S. Banerjee, Calcutta.

A correlation between the intradermal test and the blood ascorbic acid level has not been observed by some workers and, therefore, they have concluded that the intradermal test is not useful for the assessment of vitamin C nutrition of the body, considering that the blood ascorbic acid level is the best criterion for the purpose. Experiments have been performed on guinea-pigs under controlled conditions to show the relation between the blood ascorbic acid and the twenty-four hours' urinary excretion of ascorbic acid. The decolorization time in the skin test was also observed. No correlation between the urinary and blood ascorbic acid levels was obtained in normally fed and in scorbutic guinea-pigs. It seems that the urinary excretion of ascorbic acid and the blood ascorbic acid level may depend on various factors and there are reasons to doubt whether the blood ascorbic acid level would be a safe criterion for ascorbic acid status. It is possible that the vitamin C content of the skin, which is a part of the body tissues, as determined *in situ* by the intradermal test, gives a more accurate picture of the vitamin C status of the body.

15. Intradermal test as an index of vitamin C-nutrition of the body—observations at Vizagapatam.

D. V. S. Reddy *and* P. B. Sastry, Vizagapatam.

The intradermal test with 2–6 dichlorophenol indophenol suggested by Rotter as a reliable index of vitamin C status of the body has been enthusiastically recommended by some workers, while others found no correlation between the time of decolorization and the level of blood ascorbic acid or urinary saturation test.

In India, Banerjee and Guha found in their experiments that the time of decolorization was longer in scorbutic guinea-pigs and was definitely diminished when ascorbic acid was added to the diet. In human subjects also, they found that administration of massive doses of ascorbic acid resulted in the reduction of decolorization time. More recently, they reported again on experiments conducted on guinea-pigs and human

subjects; the decolorization time became shorter and shorter with increasing saturation with vitamin C and reached a minimum of 1 minute and 20 to 30 seconds. These workers suggest that the minimum decolorization time may perhaps give a truer picture of the vitamin C status of the body than the usual urine (saturation) test.

Observations and experiments were conducted at Vizagapatam on different age-groups and classes of people. The dietetic habits, clinical history and results of the skin test (time of decolorization of the dye injected intradermally) are correlated. Further investigations are being carried out to correlate the level of blood ascorbic acid and urinary saturation test with the results of the intradermal test, with a view to find out a standard procedure and time, to make the test a satisfactory index of the vitamin C nutrition of the body.

16. Investigations into the standard of dietary and state of nutrition in the leper belt of Manbhum District (Bihar).

K. Mitra *and* C. Gupta, Patna.

An investigation into food intake of 155 families residing in rural area inside the traditional leprosy belt of Manbhum District and fifty leper families in Purulia town was carried out during November 1939 to May 1940. The average daily income per consumption unit was found to vary between 0·76 to 2·65 annas. The families were mainly engaged in agricultural pursuits. The incidence of leprosy was found to be fairly high, assessed by the percentage of lepromatous cases and child lepers. About 30% of the families were found to subsist on a diet *deficient in quantity*. In four families the average daily intake of calories barely reached four figure standard. Inadequate intake of animal proteins, minerals and vitamin A was noticed in a very large percentage of families. A little more than 2,000 children residing in this area were examined anthropometrically and clinically. By clinical naked eye examination about 40% of the children were found to be malnourished. By the application of another index, Knudsen-Schiotz sign the percentage came up to about 30. About 15% of the children were found to be suffering from incipient signs of deficiency.

17. Estimation of proximate principles of food in a few edibles by chemical methods.

K. Mitra *and* H. C. Mittra, Patna.

Thirteen kinds of grain foods, 18 kinds of flesh foods, 27 kinds of fruits, 20 kinds of vegetables and 8 kinds of miscellaneous foods were analyzed chemically for their moisture, protein, carbohydrates, fats, crude fibres, calcium and phosphorus contents. Amongst the grain foods Sutari (a inferior type of cowpea) and kusumb seeds (*Carthamus tinctorius*) were found to be comparatively rich source of calcium. *Purna chawl* or rice grains with complete layer of pericarp was found to contain 2·50% of fats but calcium content did not exceed 12 milligrammes. Amongst the vegetables are included about 7 types of tubers consumed by the aboriginals.

Five kinds of *sukhua* or dried fish were analyzed. All of them were found to be very rich in all the protective dietary principles. Of the miscellaneous foods *posta dana* (*Papaver somniferum*) was found to be rich in calcium. Again, of the flesh food group Snail's meat (*Pila globosa*) was found to be the poorest in protein content (about 10%).

18. Trend of dietary habits and analysis of food budget in the working class families of Bihar.

K. Mitra, Patna.

An attempt was made to find out the influence of income on the diet in the analysis of food budget of 177 working class families at Jamshedpur (Steel works) and 194 similar families from Jharia (coal-fields). The families from each of these centres were divided into four groups in the sliding scale of income level from Rs.15 to Rs.200 per month. With the increase in income expenditure on food increased but the percentage of income spent on food diminished. This percentage was found to vary from a little over 70 to approximately 40 in the highest income level. In the lower income groups about two-thirds of the expenses were needed for cereals and pulses; with the increase in income this percentage came down to less than 30. The expenses on non-leafy vegetables, fats, fruits, milk, sugar and flesh foods maintained a positive correlation with the income level. Curiously enough the expenses on leafy vegetables behaved otherwise. In analyzing the trend of preference for different edibles in their respective classes, homepounded parboiled rice was the most popular cereal, red gram the most popular pulse, potato the popular vegetable, mustard oil the popular fat and goat's meat the popular flesh food.

19. An enquiry into the consumption of milk in a few urban areas of Bihar.

K. Mitra, Patna.

An investigation into the intake of milk in 1,600 families spread over six towns of Bihar—Jamshedpur, Gaya, Madhupur, Dumka, Dhanbad and Thakurganj. The families were classified into five income groups: (*a*) up to Rs.25, (*b*) up to Rs.50, (*c*) up to Rs.100, (*d*) up to Rs.200, and (*e*) above Rs.200. The average daily consumption per family beginning from the lowest income group was found to be 26·9, 46·6, 67·9, 92·9 and 197·1 ounces respectively. It was also found that with the rise in income level per capita consumption of milk increased and the number of non-consumers diminished. Amongst the adult population males were found to consume more milk than the females in all the income groups. In the lowest income group about 58 per cent and in the highest income group 18 per cent of the expectant and nursing mothers were not drinking any milk. The average consumption varied between 7 to 18 ounces per day. In the case of children the respective minimum and maximum figures were 5 to 15 ounces.

20. Studies on the composition of peptones. Part I.

Sudhindranath Sen, Baranagore (Calcutta).

Various foreign peptones are available in the market for biological work. There is no definite knowledge regarding the composition nor the method of decomposition of any protein body for their production. Accordingly, a work in this direction has been undertaken.

In the present paper fibrin clot as well as veal from the local slaughter house has been hydrolyzed by pepsin in acid medium at 37° for different periods. The nature and character of decomposition products have been ascertained. The solid isolated from the fibrin clot may be so adjusted as to afford a peptone quite suitable for the production of *clostridium* tetani and other bacterial toxins. Further work is in progress.

21. Availability of calcium in vegetables.

K. P. Basu *and* D. B. Ghosh, Dacca.

The availability of the calcium of the following vegetables, viz. Lady's finger (Hibiscus esculentus—Beng. Dhenras), Cabbage (Brassica oleracea capitata—Beng. Bandha kopi), Drumstick (Moringa oleifera—Beng. Sajney) and Amaranth tender (Amaranthus gangeticus—Beng. Lal shak or Dhula shak), was investigated by two different methods. In the first place young healthy albino rats which had been reared on the usual diet of the laboratory were placed on five different diets in which milk and the four vegetables were respectively the only sources of calcium. Only in the case of drumstick milk supplied 50 per cent of the total calcium. At eight weeks of age the rats were killed, the utilization of calcium was determined and compared. The utilization factors for males were 0·87 for milk diet, 0·71 for lady's finger, 0·82 for cabbage and 0·70 for drumstick diet. These values for females were respectively 0·84, 0·70, 0·81 and 0·69. Sex difference was, therefore, practically without any appreciable effect on the utilization.

A separate investigation was undertaken to find out how the calcium of these vegetables was utilized in maintaining calcium balance in human beings. The metabolism experiments were performed on an adult. The experimental subject was first given a basal diet containing inadequate amounts of calcium. The effect of supplementing the basal diet with each of the different vegetables and with milk was then observed. The average per cent retention of calcium was 50, 43, 29, 23 and 23 respectively in the case of milk, amaranth, Lady's finger, cabbage, and drumstick.

22. Biochemical studies of some species of Madras fish.

N. L. Lahiry, C. P. Ananthakrishnan, *and* B. N. Banerjee, Bangalore.

The nitrogen distribution of the tissue proteins of Mullet, Karva and Ramash has been determined by the method of Van Slyke as modified by Plimmer and Rosedale, including Damodaran's dicarboxylic acids. Tyrosine and tryptophane contents have been determined by the colorimetric methods of Folin *et al.* Karva is marked by its higher tyrosine and tryptophane contents than the other two fishes. Independent colorimetric estimation of cystine on the fish proteins indicates a lower amount for Karva, the other two being almost equal.

The present investigation relates to the study of the nature and extent of the *in vitro* digestion accompanying the treatment of the whole meal by pepsin, followed by trypsin.

Estimations have been made of various components such as calcium, phosphorus, and iron and the results discussed.

Determinations of the biological value of the muscle proteins by growth and balance-sheet methods on rats are in progress.

23. Studies in insect nutrition. Part I. Vitaminic requirements of the rice moth—*Corcyra* sp.

P. S. Sarma *and* M. Sreenivasaya, Bangalore.

The rice moth *Corcyra* sp. has been found to be an eminently suitable insect for work on insect nutrition. Preliminary experiments with the insect showed that the growth of the insects is influenced to a considerable degree by vitaminic deficiencies. Insects fed on vitamin free diets were found to respond readily and quantitatively to additions of vitamins.

Our investigations have so far revealed that the rice moth definitely requires two groups of vitamins—(1) the water-soluble vitamins which includes B_1 and (2) the fat soluble vitamins, one of the components of

which has been characterized as a sterol. The insect does not need any vitamin C.

We have employed this insect for an estimation of the vitamin B_1 content of various food materials, for a determination of the 'quality' in crops and for the assay of the vitaminic potency of biological products.

24. Assessment of vitamin B_1 deficiency of persons living on diets of Bengalis.

N. M. Basu *and* G. K. Ray, Calcutta.

The state of saturation of the body of a subject with respect to vitamin B_1 is determined by finding out what percentage of a test dose, viz. 350 I.U. of vitamin B_1, fed orally to a subject is excreted in his urine in the subsequent period of 24 hours. If the excretion amounts to 15% or more of the dose in that period, the subject is considered 'normal', but if it be less than that he is taken to be 'deficient'.

The estimation of B_1 in urine was carried out mainly by Jansen's Thiochrome method as modified by Wang and Harris, but in the case of a few subjects it was done biologically by adsorbing the B_1 in urine on Lloyd's reagent, feeding the adsorbate to vitamin B_1 deficient rats and then estimating the vitamin from their growth curve.

Twenty-two subjects were examined by the chemical (i.e. Thiochrome) method and six by the biological method. Amongst the former group 50% were normal and the rest deficient, whereas amongst the latter every one was deficient.

In the course of these determinations the following observations were made:—

(i) The total urinary excretion of vitamin B_1 per day varies between 20μg to 288μg.

(ii) As in the case of vitamin C, the daily urinary output of vitamin B_1 is not an index of the state of saturation of the body. The ratio $\frac{B_1 \text{ content in I.U. in the daily diet}}{\text{non-fat calories consumed daily}}$ is found to give a roughly approximate indication of the B_1 status of a person. The persons from whose diet the above ratio was calculated were found on examination to have kept their diets constant for a long period before these experiments. If the value of this ratio in a person be 0·3 or above, he is found to be 'normal' with regard to vitamin B_1 content of his body, but if it is less, he is found to be deficient. The ratio in the case of normal boys below 16 years is found to be 0·25.

(iii) Unlike vitamin C, after administering daily the test dose of 350 I.U. of vitamin B_1 to a person for a long time, the excretion of the vitamin may not always rise, but is very irregular, and does not become constant.

The relation between vitamin B_1, the carbohydrate content of the diet and the average yield of glucose from the protein content of the diet of a person on the one hand and the proportionate excretion of the vitamin after a test dose is being investigated.

25. Synergism between vitamins B_1 and C.

N. M. Basu *and* G. K. Ray, Calcutta.

In investigating to what extent the coagulation-time of blood is delayed by the avitaminosis of C it was noticed that the vitamin B_1 content in the food is an important factor in this respect. Experiments were, therefore, devised in the following way to ascertain if vitamin B_1 affects the effect of deprivation of vitamin C on the clotting-time of blood.

Four groups of guinea-pigs, each containing at least six, were taken. One group which was kept as a control was given the same diet as the other three groups but was given adequate amounts of vitamin C. The other three groups were placed on the scorbutic diet. Of these three groups, the 1st group received no supplement of vitamin B_1 but each member of the 2nd and the 3rd group received daily 50γ and 100γ of B_1 respectively. The administration of this supplement was continued throughout the whole period of the experiment. When the guinea-pigs developed signs of scurvy, they were given different amounts of ascorbic acid according to the intensity of the symptoms till these symptoms completely disappeared. The coagulation-time of blood of the guinea-pigs of all these groups was noted at regular intervals. On analyzing the coagulation-time of the blood of animals of these four different groups, the following results were obtained:—

(*a*) The coagulation-time of the control animals was on the average nearly 1 minute, of the group which received no supplement of vitamin B_1 increased from its normal value by 59·5 seconds on the average and of the groups which received daily supplements of 50γ or 100γ of B_1 increased on the average by 35 seconds only.

(*b*) The coagulation-time was restored to normal after the ingestion on the average of widely different amounts of vitamin C by three different groups of scorbutic animals. Thus group I which received no supplement of B_1 required each on the average 66·6 mg. of C, group II which received 50γ of B_1 required each 54 mg., and group III which received a supplement of 100γ of B_1 daily, required 30 mg. each.

It is obvious from these results that an excess of vitamin B_1 in the diet of scorbutic animals not only prevents partially the marked increase in the coagulation-time of scorbutic animals, but also helps in the restoration of the normal coagulation-time by the ingestion of smaller amounts of vitamin C. It may, therefore, be concluded that there is a synergism between vitamins B_1 and C in the maintenance of the normal coagulation-time of blood.

26. The absorption of glutamine during digestion.

M. DAMODARAN *and* K. G. ANANTHANARAYANAN, Madras.

Glutamine was shown to be a product of the digestion of proteins *in vitro* by proteolytic enzymes some years ago (Damodaran *et al*, 1932; *Biochem. J.*, **26**, 1704). Since then researches of various authors have indicated the importance of this substance in the intermediary metabolism of proteins. The absorption of glutamine from the alimentary tract during protein digestion has now been demonstrated. Blood from the femoral artery of dogs was analyzed for glutamine before and after a protein meal. A definite increase in the glutamine content of blood was found two hours after ingestion of protein.

27. The milk coagulating enzyme of *Withania coagulans*.

K. M. YESHODA, Madras.

The milk clotting action of the fruits of *Withania coagulans* is due to an enzyme which can be prepared in solid condition by the following procedure: the aqueous extract of the dried fruits is precipitated with ammonium sulphate, added to 65% concentration, the precipitate redissolved in water, and dialyzed free from ammonium sulphate and the dialysate precipitated with acetone. The dry preparation has a high activity, 30 mg. being capable of clotting 1 liter of milk in 30 minutes at

room temperature, and retains its activity unimpaired indefinitely. The enzyme is inactivated by heating to a temperature of 90° for 3 minutes. The optimum temperature for clotting is 48°C–50°C. The consistency of the clot is dependant upon the concentration of the enzyme, the higher the concentration the shorter the period for coagulation and the harder the clot.

The coagulating activity is only ¦ that of papain; the latter, however, imparts a bitter taste to the milk even in very small concentrations.

Unlike all milk clotting enzymes studied previously, the preparation from *Withania coagulans* is entirely devoid of proteolytic activity thus conclusively proving that the milk clotting and proteolytic activity of rennet prepatations are due to two separate enzymes.

28. The identity of liver arginase and canavanase.

M. DAMODARAN *and* S. MANDESWARA SASTRI, Madras.

In continuation of previous experiments (*Ind. Sci. Cong. Abstracts*, 27, 245. 1940) on the hydrolysis of arginine and canavanine by liver enzyme the effect of urea and of the amino-acids, alanine, leucine, glutamic acid, ornithine and canaline has been studied on the systems.

$$\text{arginine} \rightleftharpoons \text{ornithine} + \text{urea}$$

and

$$\text{canavanine} \rightleftharpoons \text{canaline} + \text{urea.}$$

Urea, the common cleavage product of both reactions, has little inhibiting effect on the reactions even in high concentrations. Alanine, glutamic acid and leucine effect a slight inhibition while ornithine and canaline are strongly inhibitory to both the reactions. The reciprocal inhibition of ornithine and canaline on the two reactions and the fact that a summation of activity could not be obtained when liver enzyme was allowed to act upon a mixture of arginine and canavanine at saturation substrate concentrations conclusively prove that the enzyme in liver acts upon the two substrates.

29. Competition of protein substrates towards proteolytic enzymes.

N. K. IYENGAR, Calcutta.

The proteolytic action of an acetone precipitate of platelets on the following proteins were studied by estimating the increase in non-protein nitrogen in the digest:

(1) Auto-digestion,
(2) Auto-digestion + 1% Casein,
(3) Auto-digestion + 1% Insulin,
(4) Auto-digestion + 1% Plasma proteins.

The results obtained throw interesting light on the question of competition of the different protein substrates when they are present in a mixture.

It appears from the experiments that among the proteins tested, casein is the most susceptible, then comes the plasma proteins and last of all Insulin protein. Proteins which are digested more easily than Insulin protein, appear to offer protection to Insulin from enzymic proteolysis. A study of the digestion of Insulin by pure crystalline Trypsin in the presence of high concentrations of other proteins easily susceptible to enzymic attack will throw direct light on the above hypothesis. It is proposed to extend this work on the lines indicated.

30. Dark adaptation tests in cases of clinical night-blindness due to vitamin A deficiency.

K. RAJAGOPAL, Coonoor.

(*Nutrition Research Laboratories, I.R.F.A.*)

The dark adaptation curves of five cases of night-blindness were determined by an apparatus of the Birch-Hirschfeld type constructed in the Laboratories. As compared with normal controls these showed a greatly decreased rate of adaptation and a raised final visual threshold. The administration of 216,000 international units of vitamin A in a single dose (Prepalin) brought about a change in the dark adaptation curve within six hours. Within forty-eight hours the curves had returned to normal and the patients themselves recorded the improvement in their vision in restricted light. Two of these cases had previously been treated with relatively small amounts of vitamin A through the medium of cod liver oil without striking or rapid improvement so that a high dosage of vitamin A appears to be necessary if immediate effect is to be obtained.

Pharmacology

31. Pharmacology of Benzo-nicotine.

B. B. DIKSHIT *and* B. K. NANDI, Bombay.

The pharmacological action of benzo-nicotine, a synthetic product closely related to the alkaloid nicotine, has been investigated and compared with that of nicotine. On the undifferentiated protoplasm benzo-nicotine was found to be considerably less toxic than nicotine. Qualitatively the action of the synthetic product closely resembled that of nicotine on the circulatory, gastro-intestinal and genito-urinary systems and quantitatively it was approximately one-third as active as nicotine. The mode of action of benzo-nicotine has also been discussed.

32. Alterations in the electrocardiographic features brought about by digitalis.

S. A. RAHMAN, Hyderabad-Deccan.

Electrocardiographic changes were studied on isolated frog's heart perfused with digitalis solution and also on the hearts of anaesthetized rabbits, cats, and dogs, by intravenous perfusion, in acute experiments, of 1 : 20 tincture digitalis.

The initial and the most constant change in the electrocardiographic feature was found to be a depression in the S-T interval, followed later by an infarct type of Q R S complex. These changes were more marked in leads 2 and 3. The T-wave did not become inverted. On the contrary, there was a tendency for the T-wave to become more erect and pointed.

33. Mode of action of vitamins in human system.

N. K. BASU, Calcutta.

A. Influence of growth-promoting factor of different vitamins on Anterior Pituitary (hormone) was tested, and the following facts were observed: (1) Though there is no actual relation between vitamin A and the active principle of Anterior Pituitary, in all probability this vitamin acts as a stimulus to the formation of that active principle. (2) Vitamins B or C seem to have no connection with the secretion of Anterior Pituitary Hormone.

B. Influence of Anti-diabetic factor of vitamin-B-complex on Pancreatic gland was studied next. Experiments on lower animals

showed that anti-diabetic factor stimulates the Islands of Langerhan to secrete Insulin and thus keeps the level of blood-sugar always constant.

C. Relation of vitamin C and Adrenalin gland was then studied. It was found that this vitamin stimulates the secretion of the cortical portion of Adrenalin gland and thus keeps arterial tension normal.

D. Effects of vitamins on the growth of bacteria were also tested. It was found that vitamins have no direct action on any bacteria. Action of vitamins is more of a protective nature, that is, they act more by increasing the tissue-resistance than by virtue of their actual bactericidal property.

34. Rates of action of Barbiturates.

S. C. DAS, Nagpur.

Rates of action of Evipan, Pentothal, Nembutal and Sodium Barbitone were determined by intravenously injecting gradually increasing doses and noting the time needed for onset of sleep, duration of sleep and time before advent of death (if any). The results obtained show that short-acting and long-acting hypnotics differ not only as regard the duration of action but also as regard the speed of onset of action. Two classes of deaths were observed—the immediate deaths due to direct action of the drug and the delayed deaths due to some secondary effects such as partial anoxaemia during deep narcosis.

35. The influence of Evipan sodium on heart and circulation.

S. C. DAS, Nagpur.

The intravenous injection of Evipan into cats and rabbits always causes a fall of blood pressure, the extent of the fall depending on the dose, the rapidity of injection and the route of administration. When injected into portal vein instead of the femoral vein, the same dose produced a much less fall, suggesting detoxication in the liver. The fall of blood pressure was not due to the reaction of the solution injected. Even with a small dose like 2 mg./kg. causing a just appreciable fall of carotid pressure, increase of jugular pressure could be seen, indicating cardiac affection. Perfusion of cat's leg *in situ* shows that direct vasodilator action as well as vasomotordepression both contribute to the fall of blood pressure. Contraction of the auricle strip of frog is depressed about 10% by 1 in 50,000 solution, 23% by 1 in 20,000, 60% by 1 in 5,000 and 95 to 100% by 1 in 2,000 concentration. Myocardiographic records of cat's heart *in situ* demonstrate cardiac depression even with small doses indicating that cardiac factor plays a definite part in causing fall of B.P. even with small doses of Evipan.

36. Cyanide detoxication in the rabbit and the dog as measured by urinary thiocyanate excretion.

B. MUKERJI, Calcutta.

It is generally accepted that Cyanide introduced into the system is converted into thiocyanate. This convertion of a highly toxic drug to a comparatively non-toxic substance appears to be a defence measure of the body similar to the detoxication in the liver of indol into indican, a normal urinary constituent.

Working on this hypothesis, sub-lethal amounts of NaCN were injected into a series of six rabbits and five dogs and the urinary elimination of NaSCN was measured from day to day up to eight days. A control series of rabbits was also injected with stoichiometric proportions of NaSCN and the excretion of thiocyanate was followed up as control.

The comparatively recent analytical method of Baumann *et al.* (*J. Biol. Chem.*, **100**, XIII, 1933; **105**, 269, 1934) was employed for the urinary thiocyanate determination. This method is claimed to have an error of less than 7% in quantities between 0·5 to 4·0 mg. per litre.

In the rabbit injected NaCN has been found to be almost completely converted into NaSCN. Nearly the whole of the NaCN can be accounted for quantitatively as NaSCN within a period of 4 to 7 days. In the dog, on the other hand, cyanide conversion is never complete and usually less than 50 per cent of the injected, a period of 7 to 9 days in the urine.

The possible causes for this difference in the rate of excretion of NaCN in the two animals are discussed.

37. Studies on the keeping properties of liquid extract of Ergot.

I. B. Bose *and* B. Mukerji, Calcutta.

In continuation of previous work carried out in the laboratory on the stability of liquid preparations of Ergot, further studies were made to determine the rate of deterioration of the total alkaloidal contents of Ext. Ergot Liquid, B.P. 1932. A sample prepared according to B.P. specifications was divided into four parts—A, B, C, D and maintained under the following conditions: (i) Sample A was kept in low temperature in a Refrigerator between 6–8°C.; (ii) Sample B in a dark cupboard at room temperature; (iii) Sample C in room temperature but exposed to bright day-light, and (iv) Sample D in an Incubator at about 37°C. Each sample was subjected to assay at intervals of 15 days and this procedure was continued up to 300 days.

Sample A was found to yield a total alkaloidal content of 46 mgms. per 100 c.c. from the original reading of 71 mgms. per 100 c.c. Samples B and C gave values as low as 8·3 mgms. per 100 c.c. and Sample D came down to 3·6 mg. per 100 c.c.

This study indicates that the keeping properties of liquid extract ergot are very poor indeed. Only when samples are stored in refrigerators at a fairly low temperature, there is some chance of retaining the potency of the preparation. Even then there is considerable deterioration in less than a year's time.

38. The action of certain soluble camphor derivatives on the circulation and respiration.

J. C. David *and* R. Krishnaswami, Madras.

Camphor has been very popularly used as an analeptic in spite of repeated pharmacological reports as to its inefficiency as a cardiac and medullary stimulant. Owing to its insolubility various soluble derivatives have been advocated in its place. One such derivative, camphosulphonate of diethylene diamine has been examined by us for its cardiac and respiratory actions. Our experiments show that on the heart its action can be completely explained by a peripheral stimulation of the vagus, the effect disappearing after atropinization. Any temporary effect clinically noticed on the volume of the pulse and the peripheral circulation can be shown to be due to a reflex initiated by the irritant action at the site of injection, 'Solucamphre' (Delalande) produces stimulation of the respiration in experimental animals under anaesthesia and oxygen consumption is definitely increased. This effect is also mostly abolished after atropinization. Solutions containing caffeine or strychnine show no potentiation but just an additive effect.

Anatomy and Histology

39. The relation of M. Plantaris of the Soleus muscle.

BRIJ MOHAN LAL, Hyderabad-Deccan.

(1) M. Soleus develops and increases in size and attachments as the animal advances in the scale of evolution.

(2) M. Plantaris, degenerates as the animal advances in evolution.

(3) The tendon of insertion of M. Plantaris functionally takes the place of M. Flexor digitorum brevis whenever the latter muscle is absent, and forms exclusively or partly the short tendon of the principal digit of the foot, besides giving tendons to some of the other digits.

(4) Plantaris fascia is the degeneration of M. Plantaris resulting from the suppression of the muscle.

40. A modification of Raman Y Cajals' silver impregnation technique—on celloidin embedded materials for sympathetic nerve fibres and regenerating nerve tissues.

G. K. GHOSH, Patna.

Fixation . . . . . 10% formaline or acetic formaline.

When the celloidin block is made by the method described and sections are ready, the following method for staining is adopted :

1. Wash the sections in four changes of distilled water for ½ hour.
2. Place them in 4% nitric acid for 3 minutes.
3. Wash in many changes of distilled water for 1 hour.

This step is important as any trace of the nitric acid alters the *p*H of the silver solution and the impregnation is considerably delayed.

4. Place the section in 10% silver nitrate at 37°C. (incubator) for 2 to 3 days until sections are yellowish in colour.
5. Wash the sections in distilled water for ½ to 1 minute.
6. Reduce in the following solution:

Hydroquinone	2·5 grm.
Formalin	5 c.c.
Distilled water	95 c.c.

After washing well in running tap water for some time, it was found advisable to remove the surface precipitate which frequently develop in large section, in the following way :

7. Dip the section into 2% nitric acid for 20 seconds.
8. Place immediately into 5% hyp. solution, clear in 2 minutes.

Wash well in running tap water.

9. Dehydrate in alcohol, clear in xylol and mount in canada balsam.

41. The problem of intercommunication between the pulmonary and the bronchial vascular (blood) systems.

PRABHAS CHANDRA RAKSHIT, Calcutta.

The blood supply of the respiratory tree differs in different sites—trachea—inf. thyroid artery; the bronchi up to commencement of respiratory bronchioli—bronchial artery; resp. bronchioli up to the pulmonary alveoli—pulmonary artery; pleura in man and in animals with thick pleura—bronchial artery and in animals with thin pleura—pulmonary artery. Bronchial veins drain bronchi up to 2nd or 3rd and pleura at the hilum. Pulmonary veins drain rest from four zonular sources—pleura, air sacs, respiratory bronchioles, bronchi after 2nd or

3rd order. Intercommunication may be arterial, venous, or arterio-venous. In man and in the dog arterial capillary intercommunication has been found on the walls of dependent air vesicles in the region of the resp. bronchioli. Venous intercommunication has been proved. No arterio-venous communication has been observed.

The importance of bronchial arterial supply in normal responses of the lung and the extensive collateral development of the same in pathological conditions of the pulmonary vascular system are daily becoming evident. The interrelationship between the two arterial systems in the guinea-pig and the rat has been described in this paper. Methods of investigation together with photographs of celloidin casts of the vascular systems have been incorporated. Evidences of the existence of arterial communication are present.

42. Histology of avitaminosis in insects.

B. G. L. SWAMY *and* M. SREENIVASAYA, Bangalore.

The rice moth (*Coryrus* sp.) when fed on diet free from vitamin B_1, exhibits a poor development and shows an extremely sluggish behaviour. It was thought that such insects would provide exceptionally advantageous material for conducting a histological study of the changes in tissues induced by avitaminosis. The insects being small, lend themselves to their being cut in their entirity, thus yielding sections in which all the organs could be simultaneously examined.

These histological studies have revealed that the deficiency of vitamin B_1, brings about a marked degeneration of the nucleus in almost every cell that has been examined under the microscope. The nerve tissue also shows signs of degeneration. Microphotographs and drawings of the sections illustrating the kind and extent of degeneration will be presented at the Session.

SECTION OF PSYCHOLOGY AND EDUCATIONAL SCIENCE

President :—I. LATIF, M.A., PH.D.

General Problems

1. The conception of mental inheritance.

N. N. SEN-GUPTA, Lucknow.

It is necessary to define certain terms in order that the conception of heredity may be applied to mental life. The paper attempts to give these preliminary definitions. Secondly, certain methods have lately been followed in the study of mental inheritance. These are discussed in the paper.

2. On Professor Woodworth's psychological theory.

P. S. NAIDU, Annamalainagar.

Middle-of-the-road psychology championed by Prof. Woodworth is not without its assumptions and hypotheses. No 'explanation' of human behaviour can be confined to the mere registration of *facts*. So, Woodworth's psychology is found to contain a well-defined theory which is a sort of half-way house between non-theological mechanistic behaviourism, and purposive hormism. Four important aspects of this theory have been singled out for criticism in this paper. They are (1) dynamism, (2) the concept of Sets, (3) drives, and (4) purpose. And in each case it is shown how the position held by Woodworth is untenable, because it contains an irreconcilable mixture of behaviourism and purposivism. The purposivistic elements in these concepts, it is contended here, possess great survival value. They should, therefore, be developed in the propoer direction. And when they are so developed, it is found that Woodworthian stato-dynamism flowers out into McDougallian hormism.

3. Psychology offers service.

N. MUKERJI, Calcutta.

Psychology, like civilization, has moved through various stages and the present step of its progress can be labelled as the 'industrial age'. Till the last great war activities of psychology were mostly limited within the fields of armchairs; 1914–1918 wrung all that could be utilized from every science, psychology included. Since then industrial countries all over the world have accepted whatever aid psychology could offer. Psychology got rid of inertia, it moved into nurseries and kindergartens, schools and colleges, armies and battlefields, hospitals and clinics, factories and workshops offering its service. Workers for psychology were never advertised nor the journals made fashionable, still the growth of both has been tremendously rapid. The present status of psychology is not based on breaths of discussion but rigorous scientific treatment of data obtained. This paper deals with the various resources of psychology from which practical aid has been and can be tapped; some suggestions

have also been added which could be helpful to the educational institutions in India, in their practice.

4. Drugs and mystic 'visions'.

RAJ NARAIN, Lucknow.

In considering the etiology of mystic 'visions', a possibility that readily occurs to us is the use of drugs by mystics. The question is: Are drugs in or by themselves sufficient to produce mystic 'visions'? An answer to the question is attempted by considering in detail the nature of visions induced by the major drugs (alcohol, hashish, mescal and peyote) used by mystics, and by distinguishing these from mystic visions. It is also observed that the use of drugs must be combined with a religious disposition, attitude, or temperament in order to evoke mystic visions. It is suggested that a theory of mystic visions should base itself upon those basic psycho-physical states which underlie all the diverse practices like fasting, yogic regulations and *kriyas*, suggestion, etc., that lead to visions in mystic life.

5. Growth of meaning-experience.

KALI PRASAD, Lucknow.

I.

1. Two things seem to be clear, viz. (i) that meaning in some form or other belongs to or characterizes all experience however rudimentary; (ii) that meaning develops and elaborates as the Individual grows. The variation of behavior-pattern in response to the recurring stimulus-situation shows that there is appreciation or at least a perception of meaning. Otherwise variability cannot be adequately explained. This does not imply that 'Meaning' is an *entity* or quality which *does* something to experience. On the contrary, meaning-reaction is a behavioral pattern, with specific and defined outlines.
2. The development of meaning-reaction occurs through such pervasive and elementary activities as the following: Symbolizing, Construction, over-determination of image, irreversibility, transduction, shifting orientation, etc.
3. With the rise of language meaning-experience makes yet another advance. Bean's work on pre-linguistic equipment of child. The emergence of the so-called '*Rhemes*'.
4. Further development occurs with the rise of 'Relation' like causal relation, association, synthesis and syncreticism, participations, etc.
5. The rôle of Ego-centricity, animism and artificialism in the development of meaning.

II.

1. Apart from the genetic approach we may now take up an analytical and experimental study.
2. We select a group of (i) children, (ii) adults, and they are experimented on certain materials used in our laboratory. The materials consist of, for example, ink-blots, drawings, non-sense words, unfamiliar objects and situation, concepts and general ideas.
3. Conclusions.

6. On the nature of Aristotelian abstraction.

W. BURRIDGE, Lucknow.

The Brain is the machine with which we do our thinking and its units are nerve cells which in their turn are living colloidal systems.

Such systems provide the machine with two sources of energy, and experiments with alcohol demonstrate that the one source of energy provides us with the capacity to judge our data, and that the other provides us with the data that we judge. It is inherent to the machinery that the more we use of the one source of energy, the less can we use of the other and *vice versa*. Certain motor analogies are used to show how this relationship can mislead.

Variations in the proportions of the two sources of energy provide an infinite series of thought-alloys which, for convenience, are divided into six strata or mixtures. The stratum of solid and definite fact, the eucritical, is shown to merge on the one side into the indefinite and vague or hypophasic, and, on the other side, into the paracritical, a stratum where the definitely round acquires roundness. This is also the stratum of Aristotelian abstractions.

Four ways of obtaining thought-alloys of this composition are considered without prejudice to the possible existence of others. One way is by accretion or addition, another is by abstraction. Differing methods of arriving at the same end-result naturally provide material for controversy unless one appreciates the nature of the end-result and the paths leading thereto.

7. Nature of aesthetic appreciation as revealed by introspection.

N. S. N. SASTRY, Mysore.

Recently the problem of aesthetic appreciation has engaged the attention of experimentalists, a good deal. Complicated and elaborate appliances are used to record a number of physiological changes in order to locate the physiological basis or manifestation of appreciation. And it is significant that introspection continues to play an important rôle.

Fifty thoroughly reliable persons took the test. After attending to the stimulus presented to them as long as they liked, they were asked to record their introspection. Only very rarely they were aided by indirect questions. Both music and painting were used as stimuli.

The analysis of the introspections is very interesting. The fifty subjects were divided into five classes on the basis of their aesthetic standing as judged by the group itself. The introspections reveal:—

(*a*) The absence of any discernible emotion, presence of intense pleasant feeling, transient imagery—in the highest group,

(*b*) strong and intense emotion, pleasant feeling, imagery (often very steady)—in the lowest group. There is also marked sensory experience, and

(*c*) intermediary stages in emotional consciousness in the intermediary groups.

8. The sympathetic induction of emotions.

P. S. NAIDU, Annamalainagar.

One of the most important factors in group behaviour is the sharing by all members of the same group of an emotion experienced only by a few. This phenomenon, called *Sympathetic Induction* has been analyzed by McDougall, and its potent influence over the mind of the individual as well as of the group has been established. But Prof. Allport disputes the conclusion of the great leader of hormic psychology. Three objections based on (1) experiments on the maturation of instincts, (2) experiments on the identification of emotions by photographs of their facial expressions, and (3) induction of sentiment, have been raised. This paper meets the objections, and while establishing the indisputability of *Induction*, draws attention to the prevalent sources of misunderstanding of McDougall's hormic theory of human behaviour.

9. Deterioration of psycho-physical functions in old age.

N. N. SEN-GUPTA, Lucknow.

The psycho-physical functions deteriorate in different degrees in old age. Attempts have been made to estimate the extent of such diminution in terms of objective tests. The paper gives an account of the data and attempts to interpret them.

10. On boss-subordinate relation.

PARS RAM, Lahore

Four officers in-charge of big departments employing a large number of subordinates were asked to express themselves regarding their opinion of the subordinate staff. They were allowed to speak freely of what they thought of their subordinates and in order to achieve this no notes were taken in their presence. The interview was of the nature of free association. Subordinates, according to these officers, were very good at carrying out mechanical instructions but they fumbled whenever they had to exercise judgment or had to take the initiative.

These observations suggest that boss-subordinate relationship encourages a diffusive response in the subordinate who is oriented more towards the person of the boss than towards the task. Such a relation does not suit a complex organization in which even the subordinate has to show a capacity to make judgment. An attempt is made to analyze the causes of this state of affairs.

11. The rôle of mental set in determining the course of associative reproduction.

S. M. MOHSIN, Patna.

The traditional theories of association explain the reproduction of the associated materials. They fail to account for the appropriateness of the materials to the situation of recall. The behavioristic explanation is similarly inadequate. The Wurzburg psychologists offer a satisfactory account. They explain the specification of the course of reproduction as the function of a determining tendency or mental set released on the proper acceptance of the task.

The writer's experiment on controlled association reveals the operation of a mental set facilitating certain responses and inhibiting others. The set functions by increasing the speed and efficiency of the response.

The law of perseveration or inertia describes the function of 'set'. Experiments done by Thomas, Muller and Pilzecker show how the resistance to change or perseveration facilitates certain responses and hinders others. The law of 'retroactive inhibition' in learning is also an instance of the operation of set.

Educational Psychology

12. 'Mixed sentences' in Hindi as an element of a group intelligence test.

S. JALOTA, Sholapur.

A test of sixteen items of 'Mixed sentences' in Hindi were selected from Jha's adaptation of Terman's group test. Fifty-four students of the first year, and third year class in the College were tested. The results were correlated with the University scores. The correlation was low ranging from +·17 to +·30 only. So I do not think that 'Mixed sentences' in Hindi is suitable as a test-element in a group intelligence test.

13. A test for reading ability.

SAROJENDRANATH ROY, Calcutta.

Test for reading ability forms one of the items of the Vocational Guidance examination which is now being conducted by the Applied Section of the Psychology Department, University of Calcutta, among the school boys of Bengal. The writer discusses a method of evaluating reading ability that he has been following for about a year with fairly good result. Attempt is devised and being made to prepare norms of reading ability for different age groups.

14. A note on the Bengali version of the new Terman and Merrill test prepared by the Psychology Department of the University of Calcutta.

KRISHNA CHANDRA MOOKERJEE, Calcutta.

Certain essential features bearing upon the standardization of the Bengali Version of the Terman and Merrill Intelligence Test as adopted by the Applied Section of the Psychology Department, have been discussed. The data collected so far by administration of the tests to the school boys and girls of Bengal have been scrutinized to examine the variability of the I.Q. in relation to age, the reliability of the scores, individual differences in results when tested with different 'forms', etc. From the statistical study of the available data it appears that the I.Q. variability in relation to age is approximately constant for the Bengali version of the test.

15. What is the relation between the average mark, the minimum for a pass and the percentage in an examination?

A. A. KRISHNASWAMI AYYANGAR, Mysore.

The question envisaged in the title is answered by the formula

$$p = m(dY/dX)_{X=s} \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where $100m$, $100p$, $100s$ denote respectively the percentage of average mark, the minimum percentage for a pass and the percentage of passes respectively and $Y = f(X)$ is the Lorenz curve corresponding to the frequency distribution of the marks. For getting a suitable formula the present writer has utilized a new distribution which corresponds to a cubic Lorenz curve. When the curve is thus specified, the relation (1) takes the form

$$p = 1+(6m-4)s+(3-6m)s^2 \quad \ldots \quad \ldots \quad (2)$$

where the limits for m are $1/3$ and $2/3$ and the limits of s are $1-\sqrt{p}$ and $\sqrt{1-p}$, which work out to 40% and 80% when the pass minimum is 36%.

The formula (2) implies very simple and sound principles:—

(i) reasonable limits for the average and the pass percentage;
(ii) the percentage of passes increases with the average mark;
(iii) the average mark is greater than, equal to, or less than 50% according as the percentage of the failures is less than, equal to, or greater than the minimum percentage for a pass; and thus provides a ready method of discovering discrepancies in marking.

Three indices,

$$I_1 = p/\{1+(6m-4)s+(3-6$$

$$I_2 = s(1+q)/(1-p), \text{ where } 1+3p(1-2m)/(3m-1)^2 = \{1+q/(3m-1\}^2,$$

$$I_3 = 6ms(1-s)/\{p-(1-s)(1-3s)\},$$

are suggested to measure respectively the stiffness of the questions, the performance of the examinees, and the stringency of valuation.

A more satisfactory distribution for marks is one which corresponds to the biquadratic Lorenz curve which is uniquely determined by the extreme values of the range, the modal value and the average.

16. Language test in arithmetic.

A. N. BASU *and* N. MUKERJI, Calcutta.

Object—To determine the difference in results when arithmetical sums are given in English and again in Bengali. The present experiment was conducted to examine the extent of the effect which the recent changes in regulations of Calcutta University Matriculation Examination may have produced.

Procedure—A set of test questions was prepared in English comprising four simple problems in arithmetic and four sums of mechanical nature. The set was translated in Bengali also. Each of the above sets was horizontally sectioned into two equal halves, thus we had four sets of test materials 1E and 2E, 1B and 2B. Tests 1E and 2B were applied on two occasions to 250 boys and girls of various secondary schools in Calcutta and to another 250 boys and girls tests 2E and 1B were given. Precaution was taken to see that the schools and students were chosen in a random manner. Each correct answer received one score.

Result—Statistical details of the results being given in the original paper, only a general view is supplied below:—

Total score in Bengali Test ..	= 1035
,, ,, English ,, ..	= 890
Gain over English ..	= 145 or 14% approximately.

Total scores in 'Problems' in Bengali	= 500
,, ,, 'Mechanical sums' in Bengali	= 530
,, ,, 'Problems' in English	= 369
,, ,, 'Mechanical sums' in English	= 524

Difference between the scores in Mechanical sums in Bengali and English = 6 or 1·1% approximately.

Difference between the scores in Problems in Bengali and English = 131 or 26·2% approximately.

Types of mistakes have been analyzed and their frequency determined.

Conclusion—The introduction of the mother tongue as the medium of examination would tend to produce better educational results.

17. The problem of over-age children in schools.

JIVAN DHAN BANERJEE, Dehra Dun.

It is a general feature of all schools to have on its rolls a number of over-age children in each class. A question is, therefore, often raised if the over-age children in a class are at an advantage or disadvantage due to their relatively greater maturity. This discussion would also throw a good deal of light on the probable factors determining *over-aging*. This paper, therefore, attempts to arrive at a solution of the question by an analysis of school marks.

18. A search for the qualities of good teachers.

N. MUKERJI *and* S. C. DUTT, Calcutta.

Seventy students of a B.T. class were supplied with the following question on the opening day of the class, 'What are the qualifications of

a good teacher? Mention the points only'. The results were classified and tabulated under five broad categories, (*a*) Personal equipments, (*b*) Professional preparation, (*c*) Relation with pupils, (*d*) Miscellaneous, (*e*) Negative traits. Each class was divided and subdivided into detailed traits and frequency of each trait was determined. The total number of the traits thus analyzed was about eighty.

The following five qualities received the highest frequencies in the above-mentioned categories in respective order, (*a*) Proper enunciation, (*b*) Method of teaching, (*c*) Amiability, (*d*) Moral standard of the teacher, and (*e*) Mannerism.

19. A comparative study of the essay and the objective type of examinations.

HEM CHANDRA BANERJEE, Dacca.

A comparison was made of the scores obtained by a group of boys on the two types of examination covering the same subject-matter in History and Geography. The scores indicate that an average boy knows about twice as much of the subject when tested by an objective examination as when tested by an essay type of examination. But the correlation between the points known to the boys (as determined by the two types of tests) was found to be low. In the case of more intelligent boys, i.e. boys whose I.Q. was more than 100 the correlation between the points in the two types was much higher. Thus the varying intelligence of the pupils tested is a more decisive factor in the results obtained than is the method of learning and testing used.

20. A study in the correlation of marks in an individual subject with the aggregate of marks in all the subjects, and some inter-correlations of high school subjects.

M. A. HAKIM, Lucknow.

The problem of correlation of mental abilities has been approached from many angles. This paper attempts to work out the problems on the basis of school marks. School marks on each subject may be supposed to reflect a certain kind of ability inasmuch as each implicates a specific process of learning. A correlation of marks then will reflect the correlation of these abilities. Again, the total marks, in the same manner, reflect a crude aggregate of abilities in terms of which the individual attempts to adjust himself to scholastic situation. If, then, a relation is discovered between the total marks and the marks in a particular subject it will be possible for us to estimate the value of each subject for the total scholastic adaptation. The present paper makes an attempt to bring out these points.

21. Study of school marks.

(MISS) SHANTI AGARWAL, Lucknow.

From the study of school marks it appears that the abilities of a pupil remain constant within certain limits. The marks obtained by each student during different years in different subjects are constant within certain limits.

Again, it has been said that there is a certain amount of variability from year to year in the ability of a student due to training but in the case of these students the coefficient of variability remains almost constant.

This group of students has been analyzed with respect to their constancy of performance relatively to different subjects, which, in their case, is practically the same.

Lastly, these marks are analyzed with respect to their mutual correlation. It has been found out that there is a very high degree of correlation between English and History, and Mathematics and History.

The constancy of performance suggests the presence of certain common factor. Since these girls come from approximately the same social and economic status, the common factor lies in this fact. Again, it has been supposed that girls are given to harder work than boys.

In History, English and Mathematics girls usually employ a visual schema to retain and to arrange facts. In the Vernacular they are guided by auditory-kinaesthetic (verbal) schema. The low correlation may be explained on the basis of the difference between the visual and verbal methods.

22. Variability in achievement with practice.

S. K. BOSE, Calcutta.

Whether the effect of practice under identical condition makes a group of individuals more alike or more different in their achievement, is a problem not only of interest to the scientists but is of great importance also to those dealing with public policy in education. The experimental results of different investigators show discrepancies. It has been found that while the use of relative measure, such as V, in statistical calculation indicates convergence of individual differences under equal training, the employment of absolute measure like A.D. or S.D. points to the presence of divergence throughout the period of training. The present paper (i) reviews some recent investigations in this subject, especially those by Kincaid, Peterson and Barlow, Reed, and Anastasi, (ii) considers how far the discrepancy in results is dependent upon experimental conditions, nature of task given and statistical procedures adopted, and (iii) concludes that under certain limitations the principle of 'equal opportunity for all' is justifiable.

23. Interpretation of Intelligence Test results in two specific cases.

H. P. MAITI, Calcutta.

An attempt has been made in this paper to delineate the psychological significance of individual Test item scores obtained by two brothers in an adaptation of Terman Intelligence Tests. On the basis of the analysis given it appears that in some cases at least individual test item scores and the nature of the responses under the individual items are of greater significance than the I.Q. An account is given of the educational improvement effected in one of the cases on the basis of the psychological significance of the scores and responses.

24. The home background and the new school.

JAGDISH SINGH, Lahore.

In a progressive school which is run on the lines of new education, the pioneers meet with various types of difficulties. A residential and co-educational institution on the lines of Adolph Ferrier's L'Ecole Active was established in the Punjab recently. In developing a group life among the children of that institution, the management experienced the following difficulties which reflected very prominently the home background of the children:—(*a*) Lack of a co-operative spirit in manual activity, team spirit at the playground and table manners at the dining table. (*b*) Personality problems of the children. The author examines some of the typical factors that influence a child's behaviour in the home and the way they come into play in the school. Factors such as (*a*) the social status of the family, (*b*) the order of birth of the child, (*c*) the rôle of the mother in

the home, (*d*) the attitude of the parents to the school—are examined. Some typical cases are dealt with.

25. Causes of the variance of out-turn of work in mental testing.

DWIJENDRALAL GANGULY, Calcutta.

Forms 'L' and 'M' of the Individual Intelligence Test, revised and standardized by Terman and Merrill have been modified and adapted by the Applied Psychology Department of the Calcutta University in connection with the Vocational Guidance work taken up by the department. Vocabulary test is a part of the form 'L'. Terman and Merrill vocabulary was found unsuitable as a test in this country and so it was substituted with a new vocabulary of 100 English and 100 Bengali words. This new vocabulary is yet to be standardized and a large number of data is required for the purpose. During the collection of such data, it was noticed that the out-turn of work by individual worker varied at different time intervals. This feature attracted the attention and detailed information as to the work by three different workers, working for four days each, was noted. The working period of each day was divided into eight equal intervals and out-turn of work by each worker for each period was kept in a tabular form and out-turn curves were drawn. Introspection of each worker after each day's work was taken. In discussing the possible causal factors for such variance, fatigue curves of big and small muscles taken in the laboratory of the department with the help of Ergograph and output curves in the industrial field taken from 'Industrial Psychology in Practice' have also been considered in this article along with out-turn curves obtained.

26. Mental factors in attention errors.

J. K. SARKAR, Muzaffarpur.

The main purpose of this paper is to indicate the different levels of attention errors. Tachistoscopic experiments made on 300 subjects testify to this. According to Titchener, attentive consciousness manifests two fields, the clear and the obscure, and this dual-level formation solely depends on the nature and forms of stimuli. But the obscure field or hazy margin is not only determined by conditions of stimulation but also by the tendencies or subjective factors that are brought into the stimulus-situation by the subjects. Introspective and experimental observations show that some of the attention errors are not direct but influenced reactions. They further point to the fact that every attention is a double-sided process involving depression and release.

Physiological Psychology

27. Sleep.

UDAI BHANU, Indore.

This is in continuation of the paper read last year.

Sleep is that depressed state of the brain in which the lost energy is regained. Depression is found in several diseases, like hysteria, insanity, epilepsy; but that depression is not called sleep because there is no repair.

Sleep is a state of the brain but it can very well be detected by certain explicit changes in the body. It is not at all difficult to detect a sleepy man from a waking man. It is regarded as a passive reflex. Fatigue is the unconditioned stimulus that evokes it.

There is no evidence of a sleep centre. Just as it is possible to maintain consciousness by stimulating any centre of the brain, in the same way it is possible to evoke sleep by depressing any afferent centre.

Sleep always starts from the sensory area and never from the motor area. It may be induced from any centre but it depresses the visual area first and auditory area in the last. Several persons are observed in whom sleep is detected in the eyes but the ears are working normally. We cannot produce even a solitary example in whom the ears were inactive and the eyes working normally.

Sleep and consciousness both are essential for life. But continuous repetition of a stimulus causes sleep. So we always find in a normal man either avoidance of repetition or qualitative changing of stimuli in a long continued work.

Further observation contradicts the view, held by me last year, that sleep is greatly affected by forgetting capacity. Several persons of high forgetting capacity were found to be enjoying sound sleep.

28. Brain rhythm and certain psycho-physiological variables.

BASU KUMAR BAGCHI, Calcutta.

By means of a specially constructed low-frequency, high amplification four-stage push-pull amplifier and a dynamic recorder, electrical rhythm originating in the brain was led off the scalp of unanaesthetized human subjects placed comfortably in an electrostatically shielded semi-sound proof room. The following stimuli—a sudden call, buzzer, and speech amplifier click—when they were experienced as causing a startle produced a reduction of the amplitude of the alpha rhythm, change in frequency, new patterns, or a shift of the base line. Repetition of the stimuli tended to eliminate such effects indicating cortical adaptation. Drowsiness, sleep, feeling-toned thoughts created electrical changes in the brain that were qualitatively and quantitatively different from normal ones. A verbal denial of mental choice was sometimes accompanied by recordable electrical happenings in the brain. Factors causing all the above-mentioned changes are discussed and the importance of electro-encephalography to psychology is pointed out.

Vocational Psychology

29. Analysis of some qualitative data obtained by the 'questionnaire' method from persons belonging to the *clerical* profession.

KRISHNA CHANDRA MOOKERJEE, Calcutta.

Data obtained by the use of the questionnaire method from persons belonging to the legal profession were communicated to the last session of the Science Congress. The present paper reports the results of investigation by the same method among a group of more or less successful clerks.

30. Class, vocation and intelligence.

N. N. SEN-GUPTA, Lucknow.

Attempts have been made, in recent years, to estimate the average I.Q.-values of the various social and vocational groups. The present study is a résumé and an analysis of these facts. It is found that the higher industrial occupations and professions contribute a larger number to the upper grades of I.Q. but not to the lower grades. It is also found that the lower industrial posts contribute a large number to the upper grade of I.Q. along with a larger number to the lower grade. It is suggested that selective breeding on the part of the higher occupational groups and inheritance of traits would account for the data.

31. Three anomalous cases of career-choice.

RABINDRANATH GHOSH, Calcutta.

These cases were studied in London. In each case, a career had already been chosen and a long course of training had been undertaken; and an anomaly between the vocational activities and the career-objectives had been observed. Here the failures in the training for the careers cannot be explained without assuming and understanding the unconscious motivations which found incidence in the choice of the vocations. These cases reveal a peculiar mechanism of 'stay-on' at the preparatory stage. In the vocational efforts of each case, along with a nagging and a procrastination, the following had been discovered:—the release from parental control, an intense desire for experience of a sojourn amongst people who are regarded with ambivalence, the provoking of a situation which would be difficult to cope with and which afterwards produces an expression of extreme helplessness and an experience of guilt-feeling, an expectation of punishment, a thick coat of rationalization, and a temporary oblivion and obliteration of career-objectives. These choices were made from the ideas of gains to be derived from the chosen professions and from the phantasies of benefits and power to be bestowed on them magically from their stays in England.

Experimental Psychology

32. D.L. for lifted weights (concluding report).

GOPESWAR PAL, Calcutta.

D.L. for lifted weights under the condition of continuous increase, with different standards, with different rates of change and for different observers, were determined.

Results were statistically analyzed. Weber's Law was not found to be satisfied. Definite law was obtained relating D.L. values and standards. This law was found to be more general than that of Weber.

33. A note on a significant case of mirror drawing.

P. S. NAIDU, Annamalainagar.

'Mirror drawing' is still held to be a case of learning by trial and error. But Dr. Gopalaswami and Prof. L. W. Jones have pointed out that 'intelligence' is the most important factor in this type of learning. Yet the conative factor has not been touched upon. The experiment under report here was devised to test the influence of a strong motive in a difficult task. The data presented here prove that, under a powerful motive, the very difficult task of re-reversing mentally (as in Stratton's classical experiment) the direction-reversal of the star pattern in the mirror, was achieved by the subject right at the first attempt. The conative factor must be given the place of pre-eminence in all these so-called instances of trial-and-error learning.

Psychoanalysis

34. How spontaneous drawings of children can reveal the nature of their complexes—a short communication.

(MISS) DAMAN BADHWAR, Lahore.

This paper attempts to discuss the value of spontaneous drawings of children in the diagnosis of their emotional difficulties. Two sample drawings of two problem-children from the Child and Youth Guidance

Clinic, Lahore, are used as illustrative material. They clearly indicate the influence of subtle antagonisms and feelings of revenge which, in spite of the outward manifestations of docile behaviour, persists in the child's unconscious towards his father and teacher.

35. Examination psychosis.

RAJ NARAIN, Lucknow.

A description of the examination psychosis has been attempted under three heads: (*a*) physiological, (*b*) psychological, and (*c*) pathological. The work of Brown and Velder, Smillie, Folin, Denis and Smillie, Tigerstedt, Ferrari, Bucciardi, and Dobeff and Tomoff is reported in (*a*). The results of an emotional questionnaire given to 405 students are given in (*b*). The observations of Redl, Bergler, Neumann, Stengel, and Stekel are discussed in (*c*).

The paper closes with remarks on inter-relations obtained by Brown between emotional reactions before examinations and neurotic tendency, and between Neurotic Inventory, Scores on Emotional Questionnaire, Intelligence, and Grades.

36. The unconscious in hysteria.

NAGENDRANATH DE, Calcutta.

Repression is defective in hysteria. The unconscious occupies much of the superficial layers of the mind. Higher qualities of the mind are less developed and the mind remains childlike in many respects. The superficiality of the unconscious is responsible for its easy approachability and so the subject becomes more suggestible. Occupation of the same layer of the mind by the conscious and the unconscious without mixing with each other gives rise to the various Dissociation phenomena.

37. The concept of sublimation.

M. N. SAMANTA, Calcutta.

Sublimation is a concept that has been used by a very few psychologists and that, too, in connection with abnormal psychical processes mainly. In the present paper an attempt has been made to explain psychological phenomena, both normal and abnormal, in the light of sublimation. Since the validity of these explanations lies on experimental support, the author here only gives his views and reserves experimental verifications for a subsequent paper.

38. The super-ego.

C. N. MENON, Benares.

The theory of repression presented by Freud in 1893 and 1895 failed to stand the test of subsequent clinical experience; and slowly he postulated a Super-Ego. He did not then realize how materially this modified the horizontal division of mind into layers. Towards the end of his life, however, he explained mental phenomena in terms of a dynamic interaction of factors having parts in the conscious, preconscious and unconscious.

This leads to the conclusion that the Super-Ego is not an entity but a function; that it has biological value; and that the general tendency to look upon neuroses as the tyranny of the Super-Ego over the Ego is wrong. Maladjustment is traceable not to the Super-Ego but to the whole personality. Repression may be not the blocking of one factor by another, but the interplay of aspects of an identification, 'identification being the psychological expression of the principle of unity'. An integral theory of mental life is needed.

The Freudian theory failed to be integral because it was not sufficiently dynamic. They looked upon the Super-Ego as an intruder produced at an intermediate stage by the Oedipus conflict. But the anxiety characterizing the Oedipus conflict is not different in kind from earlier anxieties. The Super-Ego is innate; the parent being only the symbol fashioned at the time when inner entities are objectivated and named. The free association method leads to the occasion when the symbol was first formed; but its meaning is as much in the present and future as in the past.

Psychoanalysis has thus lost most of its startling and revolutionary implications.

39. Love problems of college students.

PARS RAM, Lahore.

This paper aims at analysing the hetero-sexual interests of men students (ages 17–22). The material for this paper was gathered from the case histories of youngmen who sought advice at the Child and Youth Guidance Clinic. The following types of interests were observed: (*a*) Love impulses directed towards middle-aged women, (*b*) Love object was a cousin or a girl strictly within the family circle. Girls outside the family circle were looked upon with awe, (*c*) Obsessional types of youngmen did not show any deep interest in the girls they professed to love and showed a tendency to have numerous affairs. Some youngmen preferred inferior women as their love objects. An attempt has been made to find the Unconscious mechanism behind each of the types mentioned above. Biographical material has been scanned to illustrate each type. The type of love in which personal regard for the love object is dominant is rare. Some of the typical attitudes towards the love objects such as hero-worship, dependence, etc., have also been commented upon.

40. Emotional starvation in children and young persons.

K. D. GHOSE, Dacca.

The paper discusses the various types of emotional starvation in the young and its results. It presents the data collected from a study of certain cases of a clinical nature and suggests remedial treatment. A plea is put forward for the application of the principles that underlie the remedial treatment.

SECTION OF ENGINEERING

President :—C. C. Inglis, C.I.E., B.A., B.A.I., M.Inst.C.E., M.Am.Soc.C.E.

Water Supply and Sanitary Engineering

1. Separate digestion of sewage sludge.

N. V. Modak, Bombay.

Satisfactory disposal of sewage sludge is the most important problem in modern sewage treatment. The widespread use of the activated sludge process especially in large plants has resulted in a number of advances being made in the treatment and disposal of sewage sludge. It is now established that all types of sludges whether raw or digested can be dewatered and incinerated and that the adoption of a particular method is dependent upon economic and local conditions. The first part of the paper deals with the theory and practice of 'Separate Digestion Method of Treatment' in all its aspects. In the second part description of the digesting plant at Dadar and the data collected therefrom for the last three years is given. The present capacity of the Treatment Works is sufficient to deal with a flow of 4 million gallons per day (d.w.f.). The mixture of the primary and activated sludge from the preliminary settling tanks is first treated for reduction in water-content and then pumped into a digestion tank and the gases of digestion are collected and at present utilized for cooking and heating. They will also be used in future as fuel for transport in place of petrol. No artificial heating was found necessary for maintaining constant gas generation. The constant level principle is followed in regard to the withdrawal and addition of the supernatent liquor and fresh sludge. Drying is done on specially prepared beds providing an area of 1 sq. ft. per 5 gallons of digested sludge. Experiments are also being made to prepare a compost with town refuse and digested sludge to improve manurial value. The Dadar digestion tank is the first scientifically controlled tank in India and it has demonstrated that a direct return from sewage disposal works can be obtained by the digestion of sewage sludge, if the by-products of digestion can be advantageously utilized, to meet a part of the interest and sinking fund charges on the cost of installation.

2. A preliminary study of the ascent of water through soil columns resting on a water table, the loss of water by evaporation and the associated movement of salts in the soil.

A. K. Mallik, Poona.

Experiments to study the ascent of moisture and the rate of evaporation from the top surface of soil columns resting on a water table, were done using soil evaporimeters designed and constructed at Poona, Three types of soil were under investigation, the black cotton soil of Poona. the normal alluvial soil of the Punjab and the 'Bari' (alkali) soil also from the Punjab. The effect of lowering the water table below the evaporating surface on the rate of evaporation was studied by using five different distances of the water table, viz., 6 in., 1 ft., 1½ ft., 2 ft., and 3 ft. below the evaporating surface in the case of each of the three types

of soil studied. The loss of water by evaporation was measured daily for six months during the clear season of 1939. Mean daily values of evaporation for the months of January to June 1939 from the fifteen soil evaporimeters as well as from the U.S.A. standard evaporimeter are given. The results obtained show that

(1) The ascent of moisture, in the open, is less than 3 ft. in the case of Poona soil, less than 1 ft. in 'Bari' (alkali) soil and more than 3 ft. in the case of the normal Punjab soil.
(2) In all the three types of soil studied, the loss of moisture by evaporation decreases rapidly as the water table recedes below the evaporating surface.
(3) Evaporation from the 'Bari' soil is strikingly smaller than either from Poona or from normal Punjab soil. The evaporation losses from both of the latter types of soil, however, are of the same order of magnitude.

The 'Bari' (alkali) soil was analyzed before and after the experiment and the results obtained indicate that there was an upward movement of salts resulting in an accumulation in the top layers of the soil column.

3. A new intensity raingauge.

J. M. Sil, Poona.

The design and construction of a new raingauge which directly records the intensity of rainfall against time is described. Rainwater is led from an 8″ funnel into three cylindrical receivers in succession. The receivers have light floats of identical design which operate a balanced system of levers linked with the recording stylus. Rainwater collects in each receiver for one minute only and the displacement of its float at the end of this period determines a new position for the stylus. This displacement is proportional to the mean intensity of rainfall during the minute interval. Emptying of the receivers is so timed that the pen passes from one position to another without going back to zero. As the record is composed of a succession of steps for as brief intervals as one minute each, it appears as a continuous curve. The filling and emptying of receivers is operated by a clock motor specially designed for the purpose. The intensity graph is obtained on a daily chart wound on a clock-drum such as is ordinarily used with meteorological instruments of self-recording type. A diagrammatic sketch and a photograph of the instrument are given.

Two typical records obtained with the instrument are also reproduced and described in the paper.

4. Problems of ventilation in deep mines discussed with the aid of temperature-entropy diagrams.

C. W. B. Normand *and* J. M. Sil, Poona.

In meteorology adiabatic diagrams of various kinds are employed to gain insight into the behaviour of parcels of air as they rise and fall in the atmosphere. The best of these diagrams is Shaw's tephigram, which, having temperature and entropy as its co-ordinates, is of a pattern familiar to engineers. One difficulty in all atmospheric problems arises from the changing composition of the working substance; the amount of water vapour per pound of dry air is a varying quantity. Shaw's tephigram allows one to take this varying quantity into account. Also, when Shaw's tephigram is extended to slightly higher temperatures and pressures, it becomes applicable to problems of ventilation in deep mines. It enables one easily to predict how the air temperature, the wet bulb and dewpoint temperatures should vary, as the air rises or falls in a mine-shaft, provided the movement is isentropic or adiabatic. If, however, the air gains or loses heat from the walls of the shaft, the manner in which these three tempera-

tures will be affected can be deduced from the diagram. So also if the walls of the shaft are damp and if the air gains in moisture as it ascends or descends, the resulting effect on the dry and wet bulb temperatures can be gauged.

This graphical method is compared with some results calculated in 1925 by J. S. Jones and is claimed to aid insight in dealing with ventilation problems.

5. Comparative observations of evaporation of water from different types of evaporimeters.

P. K. RAMAN, Poona.

A general survey of the evaporative power of the air in India, was made in 1935 (India Meteorological Department, Scientific Note, Vol. VI, No. 61) using values of evaporation calculated according to the formula

$$E(1{\cdot}465-0{\cdot}0186B)\,(0{\cdot}44+0{\cdot}118W)\left(\frac{100}{h}-1\right)e,$$

where E is the mean daily evaporation in inches, W the mean wind velocity of the day at 4 ft. above ground in miles per hour, h the mean relative humidity and e the vapour pressure in inches of mercury.

As a preliminary to the selection of the most suitable type of evaporimeter for general use in India, the Agricultural Meteorology Section of the Meteorological Office at Poona started comparative observations with different types of evaporimeters in 1935. The paper describes the various instruments and discusses the mean values of the data obtained with the various types of evaporimeters during the period 1935–39. The rate of evaporation in inches, as measured by the different instruments, may be converted into those of a standard U.S.A. type evaporimeter, by using conversion factors. These factors are, 0·9271 for a Piche evaporimeter inside a Stevensen Screen, 1·5990 for a wild instrument in a similar exposure, 0·8503 for an open pan evaporimeter exposed to the atmosphere and 0·6213 for a Piche in the open at 4 ft. above ground. These factors depend upon the instrument as well as its exposure. Actual five-year means of the evaporation in different months of the year are also given.

For cheapness without serious loss of accuracy, the simple Piche type is a satisfactory instrument for general use. The installation of standard U.S.A. evaporimeter is advisable at Central Irrigation Stations interested in actual evaporation from large reservoirs, whereas the small Poona-type evaporimeter is sufficient for use at important experimental farms.

6. Underground supplies of water in the trap-rock zone in the Bombay-Deccan and other allied tracts.

N. S. JOSHI, Poona.

The paper gives a full account of the nature of subsoils of the Bombay-Deccan which are the source of underground supplies of water. The author draws particular attention to the fact that it is the valleys of nalas and rivers containing such deposits like Man, conglomerates and layers of sand that hold water so as to form an underground water-table and that this is possible only in situations where a rock-bar exists in or below the nala or the river bed. The popular (incorrect) belief in finding water higher up on the ridge is based on the presumed existence of underground currents which, the author points out, do not exist. The few successful wells at times situated at ridges higher up above nallas owe their supplies to the water-tables described above, the water being conveyed to the wells by conduits in the form of fissures in soft rock connecting the water-table with the well. The popular belief for which

the water diviner with Magic Wand is mainly responsible on the other hand, is based on the assumed existence of a current from the ridge to the valley.

The author particularly lays stress on the intra-trappean layers called gheru which are mainly instrumental in the existence of the peculiar formation known as hard murum and boulders and which can retain large amounts of water from the local rainfall. More exposed rock or the small depth of hard murum overlying it cannot do this. The author advocates a theory explaining the formation of these hard murum and boulders as due to the underlying gheru which forms a weak foundation and which, after exposure on sides, causes the superincumbent rock to settle unevenly and crack both vertically as well as horizontally. These hard murum and boulder layers serve to absorb large quantities of water during rains and to give out the same later on in cold weather and hot weather being conveyed by fissures to wells favourably situated or to the valleys of main streams.

The author explains with sketches the existence of perennial supplies of water on hills like Shivneri and Shingnapur as due to these gheru layers, with formation of hard murum and boulders above. Similarly, the water-supply on hill stations for health resorts like Mahabaleswar is explained by the porous laterite formations with impermeable trap rock below.

It is upon these water bearing formations on the surface of the Deccan-trap that the underground supplies of water depend and investigations for such supplies ought, according to the author, to be based upon these in combination with such factors as the local rainfall and its distribution, the frequency of floods, the normal temperature and its variation, etc. Deep bores as in alluvial tracts are not successful in Deccan-trap as there is little chance of the deeper-lying rock ever getting water down to it, so as to be stored there.

The author, however, stresses upon the advisibility of taking preliminary 3″ bores, 40′ to 60′ deep, before open wells are excavated or pumping plants with bores are installed. The author particularly advocates such bores of medium depth for potable water-supply to villages, wells being restricted to irrigation schemes.

7. A universal flow formula for turbulent conditions.

T. Blench, Punjab.

The author attempts, from a dynamical viewpoint, to derive a flow formula to cover the cases to which formulae of the Manning, Kutter, Von Karman and other types are approximations.

His basic idea is that, since Von Karman has produced a very satisfactory universal velocity distribution law covering all boundary roughness and types, provided only that the flow be turbulent, it follows that there should be a universal flow formula also covering different boundary types, and that the special formulae applicable to specific boundaries must be found from the universal one merely by correct expression of that part that deals with boundary roughness.

His formula is:

$$V = \text{abs. const. } (R/x)^{\frac{1}{6}} \sqrt{gRS} \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where V is mean velocity; R is hydraulic mean depth; S is the slope of the total energy line; g is the acceleration of gravity, and x is:

(a) For smooth boundary the laminar film thickness δ.
(b) For rough boundary a linear dimension defining protuberance height.
(c) For incoherent boundary the Lacey silt factor, f, dimensionally corrected.

If Prandtl's boundary layer theory be adapted to the laminar film it is found that

$$R/\delta \propto (VR/\nu)^{1/2}.$$

So the smooth boundary formula derived from (1) is

$$V = \text{abs. const. } (VR/\nu)^{1/8} \sqrt{gRS} \quad \ldots \quad \ldots \quad \ldots \quad (1a)$$

or, in engineering form

$$V = \text{const. } R^{5/7} S^{4/7} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1a')$$

(1*a*) is as old as Reynold's work, and (1*a'*) dates from 1804. (1*a*) is deducible directly from dimensional analysis.

For rough boundary the engineering form is obviously

$$V = \text{const. } R^{\frac{3}{4}} S^{\frac{1}{2}} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1b)$$

which is, in practice, practically Manning's fomula.

For incoherent boundary the Lacey formula

$$V = (\text{const.}/f^{\frac{1}{4}}) \,.\, R^{\frac{3}{4}} S^{\frac{1}{2}} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1c)$$

results.

The author, while appreciating Von Karman's work fully, points out that the universal velocity distribution does not completely fit data, diverging from them in the 20% of a pipe radius adjacent to the boundary, and that the Von Karman flow formula is merely the result of assuming the velocity formula to fit the whole distribution, and then integrating it. It cannot, therefore, be expected to be of final dynamically correct form in spite of its excellent fit.

8. A rational approach to the solution of a few sewerage and sewage disposal problems with special reference to Jamshedpur.

S. K. LAHIRI, Jamshedpur.

The introduction points out that the recommendation of the Royal Commission should merely form a basis of any scheme. The rainfall characteristics and equations connecting the intensity of rainfall to the time of duration of rainfall both in England and in Jamshedpur have been dealt with. The Jamshedpur equation arrived at by the author from nearly 200 observations in seven years has also been explained.

The sewerage systems specially combined and partially combined systems with Dr. Coleman's method for determination of the quantity of surface water to be allowed for in a combined system are discussed. Jamshedpur observations for its partial combined system are given in detail. Suitable sewer sections have been fully discussed and an egg-shaped sewer with a rectangular top has been recommended. The layout and general design of the Pumping Station form the concluding part of the Sewage Section. The disposal section of the paper deals with stream pollution and disposal by dilution. Uses of deoxygenation, re-aeration curves and formulae, etc., have been explained. A summary of results for Jamshedpur on dilutions available, minimum oxygen content, B.O.D. value of effluents allowable for discharge and preliminary percentage on purification on B.O.D. value have been summarized. Brief statement on partial purification and sludge re-aeration is the concluding part of the paper.

Fuels and Internal Combustion Engines

9. Utilization of Indian vegetable oils as lubricants in internal combustion engines. Part II.

J. S. Aggarwal, H. D. Chowdhury, S. N. Mukherji, *and* Lal C. Verman, Calcutta.

A series of Air Ministry Oxidation Tests (modified) were undertaken on various oils—castor, groundnut, cotton seed and rape with and without the admixture of stabilizers, with a view to determine the physico-chemical changes taking place in oils when subjected to severe oxidation conditions. As a result of this work a number of effective stabilizers were discovered for various oils. Based on these results, which have been published in Part I of this series of papers, a number of blends of different oils were developed, having the requisite viscosity characteristics for use as lubricants in internal combustion engines.

The engine equipment consisted of a 2 H.P. single cylinder engine and a 14 H.P. 4-cylinder engine, both coupled to electric generators for the purpose of loading. Both of these engines, and particularly the larger engine, were suitably modified and a number of test accessories were provided to obtain adequate control of the various operating conditions, such as power output, speed, cooling water temperature, intake mixture temperature, oil pressure, ignition advance, etc.

Preliminary tests of 100 hours' duration were carried out in the small engine on a couple of vegetable-mineral oil blends and seven vegetable oil blends. Of these, two oil blends were found to be most satisfactory and these were tried in the larger engine for 100 hours. For comparison, runs were also made on both engines with two reputable makes of mineral oils. Oil samples were withdrawn from the crank-case at intervals during the run, and at the end of the run; these were thoroughly examined for the various chemico-physical changes, sludge production, iron contamination, etc. Engine parts were carefully measured to an accuracy of 0·0001″ before and after the runs with a view to determine wear. Wear of the top piston ring was determined by weighing with the same end in view. Carbonaceous and other deposits taking place on various parts of the engines were carefully observed and recorded.

After a thorough examination of all the data collected it was found that satisfactory vegetable oil blends could be prepared which would compare favourably with mineral oil lubricants in almost all respects, with the exception perhaps of the carbon deposit on piston top, etc., which was slightly more in case of vegetable oil blends than in case of mineral oils. But this is not considered a serious drawback, for it does not interfere with the smooth operation of the engine. As a matter of fact one of the vegetable oil blends tried actually proved superior to mineral oil in respect of sludge formation and iron dissolution from engine parts, furthermore, two blends also gave less increase in viscosity than the reference mineral oil.

As a result of these investigations two types of blends can be confidently suggested for use in medium size internal combustion engines —castor oil—rape oil blends and castor oil—groundnut oil blends. It is important that the oils before blending be thoroughly refined. As a good stabilizer for these blends alpha-naphthylamine is suggested, which may be used in proportion of not less than 1%. The proportion of the two oils to be used to form the blend will depend on the viscosity of the lubricant required. Generally, for medium size engine requiring medium grade of oil about 55–60% castor oil to 40–45% rape or groundnut oil should suffice. A somewhat higher viscosity of vegetable oil blends (say 5 to 10% higher) as compared with that of the corresponding mineral oil recommended for a given engine is considered to be desirable.

10. Methylated spirits as a fuel in petrol engines. Part I.

G. RAMA RAO, Hyderabad-Deccan.

The object of this work is to find the suitability of methylated spirits as a fuel in a petrol engine and to determine the conditions under which it could conveniently be substituted for petrol. The engine used in these trials is a 4·5 H.P. Lister Stationary engine with anon-floating type of carburettor, a jet with a needle valve adjustment and an air control device. A rope brake is provided on the fly wheel for loading the engine. The engine is started from cold on petrol and then run on spirits. The fuel consumption per BHP hour, the overall efficiency, the mechanical efficiency for various air and jet adjustments are obtained and compared with those for petrol. Small quantities of naphthalene are added to the spirits to enrich the fuel with carbon and the mixtures are tried.

11. Methylated spirits as a fuel in petrol engines. Part 2.

G. RAMA RAO, Hyderabad-Deccan.

The engine used in these trials is a 1939 model 30 H.P. Ford V8 engine with an aluminium cylinder head. The engine is fixed on test bed and is loaded by a hydraulic dynamometer. Fuel consumption per BHP hour, the overall efficiency for different jets and different fuel levels in the carburettor are obtained.

Mechanics

12. Vibrational characteristics of ground and buildings.

S. K. BANERJI, Poona.

A review is made of the observation of vibrations of buildings, dams, bridges, rock and soft ground under the California Seismological programme. The Shell Oil Co.'s building, 381 feet high (29 stories) at San Francisco vibrates in its gravest mode with a period of 1·9 secs., and the maximum building displacement is ·0028 inch.

Some observations on the vibrations of ground and building were made at Colaba by self-recording seismographs (horizontal and vertical components). In these experiments, the exciting agency was a known weight dropped from a known height. A definite energy, which could be calculated was thus communicated to the ground, and the resulting vibrations in the ground and building could be calculated theoretically. The amplitude of the horizontal component of the ground movement was found to decrease with distance approximately according to the theoretical law (distance)$^{-\frac{1}{2}}$. The periods of the forced movement of the ground depend upon the duration of impact and the elastic constants of the ground. When a weight of 12 kilogrammes meets the ground with a velocity of 4 metres/sec., the amplitude of the ground movement at Colaba is about 12μ at a distance of 10 metres and 5μ at 20 metres and the period of the forced vibrations is 0·05 sec. The free period of the rectangular building (height 21 ft., breadth 11 ft.) in which the instruments were housed is 0·014 sec.

Electrical Engineering

13. On the mechanism of band-pass effect in electric wave filter terminated in negative impedance.

S. P. CHAKRAVARTI, Calcutta.

The paper relates to investigations on the mechanism of 'band-pass effect' which has provided a new means whereby low-pass or high-pass

filter can be *converted* to band-pass filter and gain can be introduced into the transmission band of the same, by negative impedance termination of suitable magnitude.

The band-pass arrangement resulting from a symmetrical low-pass or high-pass filter section and a negative impedance termination is unsymmetrical from gain (or attenuation) and phase-shift points of view. It has been found that variation of network gain or loss of the equivalent network (formed from the original section and negative impedance termination) with frequency contributes little to the band-pass action, whereas the variation of reflection gain or loss between characteristic impedance of the original filter and negative impedance of the termination with frequency contributes mainly to it. The nature of variation of reflection gain or loss with frequency which intensifies the band-pass effect in total insertion gain or loss characteristic is largely due to variation of the negative impedance with frequency. It has been found that the cut-off frequencies and the sharpness of cut-off of the arrangement depend upon the magnitude of the negative impedance termination relative to that of the characteristic impedance.

14. The dielectric strength of Indian vegetable oils.

S. Chakravarty *and* P. C. Mahanti, Calcutta.

It is now being felt that Indian oils should be used for technical purposes where possible, with a view to ascertain their suitability as transformer oils or for use in oil switches and oil-filled condensers, a series of tests of their properties with special reference to their electric strength, dielectric constant, dielectric loss and power factors are being conducted. The object of the present paper is to report the preliminary results which have been obtained on the electric strength of some of these oils.

For this purpose the method adopted is that described in B.S. Specification No. 148, 1927. With the help of a Kenotron rectifier the voltage applied across the spark gap has been made unidirectional. Beginning from a voltage of 20 KV per cm. length of the spark gap and increasing it in suitable steps, a limit of 50 KV per cm. was reached. Of the fifteen oils studied only one of them known as the wood oil broke down at 46·5 KV per cm. The effect of impurity and moisture, on the breakdown voltage has also been studied. These results have been discussed in the present paper.

Proceedings of the Twenty-seventh Indian Science Congress

MADRAS SESSION, 1940

ERRATA AND ADDENDA

Part IV, page 41, line 21—

Read

'peaty substance'

instead of

'petty substance'.

Part IV, page 42, line 20—

Read

'illth'

instead of

'filth'.

Part IV, page 42, line 29—

Read

'Packaging'

instead of

'Packing'.

Part IV, page 58, line 21—

Read

'Dr. B K. Vaidya and Dr. K. Venkataraman, Bombay'

instead of

'Dr. K. Venkataraman, Bombay'.

Proceedings of the Twenty-eighth Indian Science Congress

PART IV—LATE ABSTRACTS, ERRATA AND ADDENDA, DISCUSSIONS, LIST OF MEMBERS AND INDEX

CONTENTS

1. LATE ABSTRACTS

Section II. Physics.

3(*a*). Measurement of acoustical impedances.

(MISS) CHANDRA KANTA, Allahabad.

The terminal impedances of air column are determined by measuring the electrical impedance of a moving coil receiver unit when it vibrates in the air column. Beat Frequency Oscillator and Campbell's Inductometer are used for making the measurements. The importance of this method is that both the acoustical resistance and reactance can be separately determined. Hence the coefficient of reflection and phase of the terminating surface of the air column can be found out.

Data have been obtained for commercial acoustical materials and other artificial materials also. There is no relation between phase and coefficient of reflection in the case of ad hoc commercial materials, but in the case of an artificial material consisting of capillary tubes the phase increases while the coefficient of reflection decreases. Acoustical resistances of orifices and resonators have also been determined. The resistance term of a resonator is found to increase hundred times for the same orifice at the resonance frequency.

12(*a*). A new method for the determination of J.

A. G. CHOWDHURI *and* D. S. KOTHARI, Delhi.

The paper describes a modification of Laby and Hircus' method. The rotating magnetic field is here replaced by a non-rotating magnetic field. The angular velocity in Laby's method here corresponds to a factor Rx/L, where R is the resistance, L the self-Inductance, and x is a length.

13(*a*). Magnetic studies on single crystals of the pyrite and marcasite groups.

D. V. KAMAT, Calcutta.

Magnetic measurements have been made on single crystals of marcasite (FeS_2), arsenopyrite (FeAsS), chalcopyrite ($CuFeS_2$) and pyrite (FeS), which are all feebly paramagnetic. Marcasite crystal is orthorhombic, and exhibits a very pronounced magnetic anisotropy: along the '*c*' axis of the crystal the susceptibility per gram molecule of FeS_2 is about 90×10^{-6} whereas along the '*a*' and '*b*' axes the susceptibility is very small, about 6×10^{-6}. Arsenopyrite crystal also is orthorhombic and the susceptibilities along the '*a*' and '*b*' axes are nearly equal, 68×10^{-6} and 66×10^{-6} respectively, per gram molecule of FeAsS, whereas the susceptibility along the '*c*' axis is equal to 83×10^{-6}. Chalcopyrite, which is tetragonal, is on the other hand almost isotropic, with a susceptibility of about 95×10^{-6}.

These results are discussed in relation to the magnetic contributions from the conduction electrons in the crystals.

37(*a*). The structure of liquid PCl_5.

BISHAMBHAR DAYAL SAKSENA, Cawnpore.

The Raman spectrum of liquid PCl_5, studied by Moureu, Magat, and Wetroff (*Proc. Ind. Acad. Sc.*, *A*, 1938, **8**, 356), shows two polarised lines 392 and 100 and four depolarised lines. The authors, therefore, conclude that the molecule has the triangular bi-pyramid structure. Using the most general energy function, the force constants are calculated by taking the two polarised lines as the totally symmetric vibrations of this model. Without the intra-valence force constant, the calculated value of the P–Cl force constant in PCl_5 is greater than its value in PCl_3 although the P–Cl distance in the former is greater than that in the latter; and the Cl–Cl force constant appears negative, although it is positive in other compounds. If the intra-valence force constant is also used, it shows a very high value, although its value is generally very low. These considerations suggest a different structure for the molecule.

The square pyramid model, with the phosphorus atom at the centre of the square, is suggested as the likely structure. The frequencies calculated for the totally symmetric vibrations of this model, with the force constant of P–Cl valence = 1·53, of Cl–Cl repulsion = ·2, and of Cl

\

P—Cl deformation = ·01 × 10^5 dynes/cm., compare very favourably with the observed frequencies, while the force constants also have reasonable values. This structure gives a positive dipole-moment in agreement with the results of Trunel, and also enables us to understand the two different chemical reactions of PCl_5 as $PCl_4 \cdot Cl$ and $PCl_3 \cdot Cl_2$ at lower and higher temperatures. It is suggested that the existing Raman data are incomplete, and that an infra-red study will be particularly useful in deciding the structure.

37(*b*). Fourth positive group of CO bands.

B. M. ANAND, Lahore.

Working with one metre normal incidence vacuum grating spectrograph, giving a dispersion of 17·6 A/mm. a number of spectrograms have been obtained in which only the fourth positive group of CO bands appears very prominently. The excitation conditions were rather novel, as no CO was fed from outside. The discharge was passed in the residual gases given off as an Acheson graphite tube resistance furnace put in the vacuum system was being degassed by heating it to about 1000°C. and the whole system being exhausted by a four stage mercury diffusion pump.

Measurements are taken of 65 band-heads between 1280–2090A, which show very good agreement with those of previous workers. A number of new band heads are reported. Seventeen of these bands show a sort of structure each consisting of about five lines. (1, 1) band with head at 1559·2 A shows five lines which coincide with five members of Q branch, i.e. $Q(25)$, $Q(29)$, $Q(33)$, $Q(37)$ and $Q(41)$ as reported by R. N. Read. The fact that only members after $J = 4$ appear may be pure coincidence, for the rotational structure cannot be resolved by the instrument if all the members are present and it is difficult to postulate conditions when only particular members after $J = 4$ should appear.

44(*a*). A demountable electron-diffraction camera.

P. K. KICHLU *and* B. M. ANAND, Lahore.

A description of a camera suitable for electron-diffraction work is given. No wax joints are needed and the whole system employs only

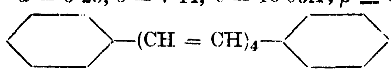
rubber gaskets. Provision is made for visual observation and a number of exposures on the photographic plate can be given in one setting.

53(*a*). The space group of the orthorhombic crystalline modification of diphenyl octatetraene.

S. L. CHORGHADE, Calcutta.

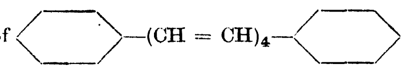
It has recently been found by Krishnan, Chorghade and Ananthapadmanabhan (*Nature*, 1940, **146**, 333) that diphenyl octatetraene crystallizes in two different modifications, one of them monoclinic and the other orthorhombic.

The crystal structure of the monoclinic variety has been studied by Hengstenberg and Kuhn (*Zs. Kristallog.* A, 1930, **75**, 301). Its unit cell has the dimensions

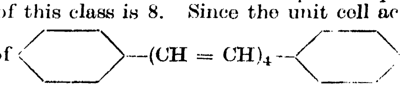
$a = 6{\cdot}25$, $b = 7{\cdot}44$, $c = 16{\cdot}03$Å; $\beta \simeq 90°$, and contains two molecules of . The planes of the type ($h0l$) are found to be halved if h is odd and those of the type ($0k0$) if k is odd. The space group, therefore, is $C^5_{2h}-P2_{1/a}$, the molecules possessing a centre of symmetry.

A determination of the space group of the orthorhombic modification of diphenyl octatetraene is made on the basis of rotation and oscillation photographs. The unit cell has the dimensions

$$a = 9{\cdot}95, \quad b = 7{\cdot}55, \quad c = 19{\cdot}75\text{Å},$$

and contains 4 molecules of .

It is found that the ($0kl$) reflections are halved if l is odd, the ($h0l$) reflections if h is odd, and the ($hk0$) reflections if k is odd, and the (hkl) reflections show no characteristic absences. The crystal is, therefore, based on a simple orthorhombic lattice, and belongs to the space group Q^{15}_h (Pcab) in the holohedral class.

The number of asymmetric molecules in the unit cell required to produce the symmetry of structure of this class is 8. Since the unit cell actually contains only 4 molecules of , the molecules must possess some element of symmetry, evidently a centre of symmetry, as is observed in the monoclinic modification.

Section III, Chemistry.

1. Synthesis of *o*-nitro-diaryl thioethers.

K. S. VENKAT RAMAN *and* N. H. MALANI, Benares.

A few *o*-nitro-diaryl thioethers were required for some synthetic work and it was found that a very few derivatives have been prepared before. With a view to obtaining these compounds in good yield, the condensation of *o*-bromo-nitrobenzene, 2 : 5-dichloro-nitrobenzene and 2 : 5-dibromo-nitrobenzene with thiophenol, *o*-, *m*-, and *p*-thiocresols has been effected in presence of potassium hydroxide and copper-bronze according to the method of Mauthner (*Ber.*, 1906, **39**, 3598) and the following compounds have been obtained:—2-nitro-2-methyl diphenyl

sulphide, m.p. 86°, 2-nitro-3-methyl diphenyl sulphide, m.p. 86-86/5°, b.p. 222°/18 mm., *2-nitro-4-methyl diphenyl sulphide, m.p. 87/5°, 2-nitro*-4-chloro-4-methyl diphenyl sulphide, orange prisms, m.p. 121° and 2-nitro-4-bromo-4-methyl diphenyl sulphide, m.p. 124°.

2. Extraction of coal with dioxane as solvent.

J. K. CHOWDHURY, Dacca.

A sample of Assam coal (Ledo) was extracted with dioxane which at atmospheric pressure was found to act better than any other neutral solvent. The temperature of extraction was low (101° to 170°C.) and hence thermal decomposition of the coal substance was avoided. The solvent could easily be removed from the extract with which it did not enter into chemical combination.

The extracted bitumen was fractionated by means of various solvents and the properties of each fraction was compared to corresponding benzene extraction product. The original coal contained a high percentage of organic sulphur (4·2%). Only a small fraction of the sulphur-compounds can be extracted by dioxane or any other solvent.

3. Acetone from alcohol.

N. R. DAMLE *and* A. N. KOTIBHASKAR, Bombay.

It has been reported that when a mixture of alcohol vapour with steam is passed over iron oxide catalyst, alcohol is converted to acetone. No detailed investigation of this reaction has been reported in the literature. Experiments were, therefore, undertaken to find: (1) the most suitable catalyst, (2) the optimum temperature, and (3) the optimum ratio of alcohol and water. So far experiments with a mixture of iron oxide and calcium oxide have been carried out.

The optimum temperature for this catalyst is found to be 570°–580°C. The optimum ratio of alcohol vapour to steam is found to be 1 : 5. Under these conditions, the yield of acetone is 43–48% on the weight of alcohol taken. This comes out to be 80% of the theoretical yield.

4. Preparation of active carbon from rice and betelnut husks. Part I. Zinc chloride method of activation.

J. K. CHOWDHURY, Dacca.

Various conditions of activation have been studied and a product obtained which compares favourably with highly active commercial carboraffin—paddy husk carbon, however, gives a slightly higher activity than carbon from betelnut husk. Generally speaking, activity increases with concentration of zinc chloride solution used. Both yield and activity are satisfactory when activation is done at 350° though the activity can be further increased by raising final carbonization temperature. Activity was measured by adsorption of iodine, methylene blue and of acetic acid.

5. Preparation of active carbon from rice and cocoanut husks. Part II. Activation by the action of gases.

J. K. CHOWDHURY, Dacca.

Active carbon was prepared in two stages. A relatively inactive carbon was first produced by carbonization at different temperatures with and without the addition of boric acid and each of these primary products was activated at 900–950°C by the action of carbon dioxide, steam and a mixture of carbon dioxide and steam for different periods of time with varying rates of flow. The yield and activity (iodine method) were

determined in each case. Addition of boric acid was found to increase the yield and activity considerably. Steam activation was found rather slow in comparison with CO_2 activation. Comparing products of approximately equal activity, the best yield was obtained by using a mixture of steam and carbon dioxide for activation.

6. On the universal colour-reaction for sterols and steroidal compounds.

M. C. NATH *and* M. K. CHAKRABORTY, Dacca.

Application of the new reaction which has been proposed to call 'The universal colour-reaction for sterols and steroidal compounds' has been discussed.

The test though not specific only for a particular sterol, can give some indications of the presence of double bonds and some other groups through the rapidity and nature of the rings formed.

The reaction being a very sensitive one, it is also possible to predict the presence of a steroidal compound in a crude natural product.

7. Quick method for the dissolution of iron from haematite.

P. L. KAPUR, Lahore.

A number of methods have been recommended for the rapid dissolution of haematite in hydrochloric acid. According to one the mineral is heated with strong hydrochloric acid and nitric acid. According to another the mineral is heated with concentrated hydrochloric acid and potassium chlorate. The method that is commonly used consists in heating the finely divided haematite with concentrated hydrochloric acid in the presence of stannous chloride. But for dissolving haematite by any of the above methods the time required is very large. It has been observed, however, that if the mineral be heated with concentrated hydrochloric acid in the presence of sodium hydrosulphite the dissolution is accomplished in a much shorter period.

8. Magnetism and Catalysis.

Chlorination of chloroform in the presence of ferric chloride.

N. A. YAJNIK, P. L. KAPUR, Lahore *and* S. S. BHATNAGAR, Calcutta.

Gault and Traffault observed that chlorination of chloroform is inhibited by ferric chloride and they showed that it was due to the absorption of active radiations responsible for the chlorination of chloroform. We have investigated this reaction from the magnetic standpoint and hence shown that water acts as a catalyst in the chlorination of chloroform. The inhibition of this reaction by ferric chloride has been shown to be due to the formation of a complex of ferric chloride and water and to the absorption of active radiations by this compound.

9. On some aromatic sulphoxides.

S. C. NIYOGY, Calcutta.

The activity of aromatic sulphonic acids and sulphones against certain bacterial infections is now well established. On the analogy of trivalent aromatic arsine oxides which have been found to be more active than trivalent arseno derivatives or pentavalent arsenic acids, an attempt has been made to prepare some aromatic sulphoxides with a view of finding their physiological activity, if any, against some common bacterial infections.

Section IV, Geology.

1. The petrology of Nayagarh State (Eastern States Agency).

D. R. S. MEHTA, Calcutta.

The rocks of Nayagarh State consist of two main groups: metamorphosed sediments, i.e. Khondalites, and the igneous intrusives.

The Khondalites are composed of graphite, sillimanite schists, garnetiferous granulites and gneisses, and quartzites. The rock facies are similar to those observed in other Khondalite areas of India.

The igneous intrusives are of two types. One type contains hypersthene as an essential constituent, and can be related to the charnockite series of Madras and other parts of the Eastern Ghats. The other type does not contain hypersthene and is not, therefore, genetically related to the charnockites.

The charnockites of Nayagarh State consist of rocks ranging in composition from granite to norite. The acid charnockites are rich in quartz and potash felspar. The quartz is bluish in colour and shows acicular dot-like inclusions under microscope. The potash felspar is generally orthoclase and shows the development of perthitic, micrographic and myrmekite intergrowths. Norites consist of basic plagioclase (varying from labradorite to bytownite), hypersthene and augite or diopside. Garnet is common only in basic charnockites. It shows vermicules of quartz, and occurs replacing the hypersthene in the rocks. The associated rocks which are genetically related to charnockites are garnetiferous leptynites and quartz-felspar rocks. The author regards the charnockites to be of igneous origin.

The non-hypersthenic intrusives include lamprophyre, graphic granites, orthite-pegmatite, norites, pyroxenites, etc. They occur as dykes and veins and are regarded younger than the charnockites.

2. Petrology of the Rajnagar asbestos area, Seraikela State.

K. K. SEN-GUPTA, Dhanbad.

The Seraikela asbestos has been so far regarded as amphibole asbestos, but the author's investigations have revealed that the mineral is genetically connected with serpentine derived from olivine and pyroxenes of the associated ultra-basic rocks and that it is chrysotile asbestos.

The main rocks of the area are granites, dolerites, ultra-basic igneous rocks (peridotites) and actinolite schists. The actinolite schist and peridotite occur as enclaves in granite; and dolerites have intruded along the joint planes of granite. Peridotite has altered into serpentine.

Evidence in this field is in favour of the hypothesis that serpentinization is the result of alteration of peridotite by magmatic water. This magmatic water is probably genetically related and subsequent to the acid intrusions. Association of calcite with serpentine is a confusing factor, for its presence is tempting for forming the conclusion that serpentinization is a result of weathering. But it is well known that juvenile water is capable of changing olivine into serpentine; serpentine into talc and magnesite and hematite. Similarly, it can also change actinolite into talc, chlorite and calcite. This calcite might have been deposited in the asbestos veins.

The asbestos occurs in serpentine in the form of slip-fibre veins. The fibres are unusually long, sometimes as much as 2 feet 10 inches in length and of great tensile strength. Further, a study of the optical properties of the mineral confirms that this asbestos was originally formed as cross-fibre veins, the type in which chrysotile asbestos usually occurs, but it has subsequently graded into the slip-fibre variety. Its unusual length is accounted for by the fact that it has been formed by coalescence of several fibres.

Section VIII, Entomology.

13(*a*). Studies on the biology of the giant mealy bug, *Drosicha stebbingi.*

KHAN A. RAHMAN *and* ABDUL LATIF, Lyallpur.

The eggs of the pest usually hatch out during the second or third week of January. Hatching is completed in 25–35 days at Lyallpur and according to Lefroy, in 2 days at Pusa. The female passes through three, and the male through two, larval instars; the males have a pupal instar also. The various instars are completed in 76–138 days as follows: first instar 44–74, second instar 17–38, third instar 15–26. The pupal stage occupies 9–15 days.

The females copulate in April, when their ovaries are not yet fully developed. Polygamy and parthenogenesis occur in this pest.

The females start to lay eggs in the second week of May and continue to do so till the end of June. Each female is capable of laying 51–372 eggs in her lifetime. She lays the largest number of eggs at 25°C.

The egg stage lasts from May to January (eight months) under field conditions, whereas it lasts for 5½ months in the laboratory at 20°C.–25°C. temperature.

13(*b*). Preliminary observations on *Phycita infusella* Meyr.

KHAN A. RAHMAN *and* ATIQUR RAHMAN ANSARI, Lyallpur.

The cotton bud moth is a widely distributed insect in the Punjab. In addition to cotton, it also infests *Hibiscus cannabinus, Hibiscus sabdariffa, Malvastrum tricuspidatum, Solanum melongena,* etc. etc.

The moth is grayish in colour with fuscous specks all over and black marginal dots on the fore wings. A female lays 17–20 slightly flattened, yellowish green eggs. They are usually laid singly along the veins on the underside of tender leaves. The egg stage lasts for 3–6 days. The caterpillar is green with black head and prothorax, during the first 5 instars but changes to red with brown head and prothorax in the 6th instar. The caterpillar stages last 25–40 days during April–November. The pupa is green when fresh, but ultimately turns to chocolate brown, its tip being furnished with six circinate hairs. The adult emerges after 9–12 days during April–October.

The caterpillars which emerge in the 1st week of October enter into hibernation among dry leaves from the middle of November. The adults from these appear in April. All stages of the pest are present during April–October.

The pest is parasitized by *Bracon kitcheneri* D. & G., *Microbracon lefroyi* D. & G. *Oncochalcis rufescens* Cam., and *Apanteles* sp.

20(*a*). Effect of different temperatures and humidities on the development of citrus Psylla (*Diaphorina citri* Kuw.).

KHAN A. RAHMAN *and* DINA NATH TANDON, Lyallpur.

Citrus Psylla is an outstanding problem of the citrus growers in the Punjab and in spite of regular spraying operations against it the pest multiplies and grows out of all proportions during certain years. The present studies were undertaken to find out the ecological factors which favour its multiplication. Only preliminary observations have been made so far but the data collected are interesting.

32(*a*). Coccid pests of citrus trees.

KHAN A. RAHMAN *and* ATIQUR RAHMAN ANSARI, Lyallpur.

Following 12 species of Coccids have so far been recorded from Citrus from Lyallpur, viz. *Aonidiella aurantii* (Mask.), *A. citrina* (Coq.), *A. orientalis* (Newst.), *Chrysomphalus* sp., *C. ficus* Ashmd., *Coccus discrepans* (Gr.), *C. hesperidum* Linn., *Drosicha stebbingii* (Green), *Lepidosaphes beckii* (Newn.), *L. gloverii* (Pack.), *Pinnaspis aspidistrae* (Sign.), *Pseudococcus filamentosus* (Ckll.). The commoner of these are briefly discussed below:—

1. *Aonidiella aurantii* (Mask.) is the "California Red scale". The female scale is circular in shape and yellowish green in colour; it appears dull red in colour because of the reddish female insect below. Besides citrus, it feeds upon an extensive list of varied fruit trees, shrubs, ornamental plants and creepers, but is fairly abundant upon guava, jasmin, 'jamman', mulberry, rose and grape-vine.

2. *Aonidiella orientalis* (Newst.).—The 'Oriental Yellow scale' is yellowish to light brownish yellow in colour, the adult female being ovate, yellow brown in adult life and roundish at maturity. Besides citrus it is recorded from 'ber', fig, guava, 'jamman', 'lasura', mulberry, 'shisham', grape-vines, etc. *Thea bisoctonotata* M. and an unidentified chalcid check it successfully.

3. *Drosicha stebbingi* (Green) is well known as 'Mango Mealy bug'. In addition to citrus it has also been recorded from about 45 food plants: apple, 'ber', cherry, duranta, grape-vine, guava, holyhock, 'jamman', jasmine, 'Kaner', 'Kachnar', 'loquat', mango, mulberry, peach, pear, plum, 'pipal', rose, 'siris', 'shisham', walnut, etc. etc.

4. *Paeudococcus filamentosus* (Ckll.).—This coccid is popularly known as 'Fluffy Mealy bug'. It is gregarious in habit, its nymphs collecting in masses on twigs, leaves and fruits. They cause malformation of the terminal growth. The adults secrete white cottony filaments and form white falted ovisacs. In addition to citrus it has been recorded from *Cynodon dactylon*, *Ficus* sp., grape-vine, *Hibiscus* sp., 'lasura', mango, mulberry, Sorghum halepense, etc. etc. A number of coccinellids including *Scymnus* sp. and a parasite wasp check it. Ants protect it from natural enemies.

39(*a*). On certain important features in the Morphology of the Grain Weevils, *Sitophilus oryzae* (L.) and *Sitophilus granarius* (L.).

MOHD. QADIRUDDIN KHAN, Hyderabad-Deccan.

The grain weevils are of great economic importance. No work has yet been published on the comparative morphology of these weevils. The author has dealt with in detail the morphology of the weevils, *Sitophilus oryzae* (L.) and *Sitophilus granarius* (L.). Special attention has also been paid to certain parts which have been misinterpreted in many other insects. Apart from minor differences in the structure of these two species the main variations in the following parts have been fully discussed:

1. Hind wings.
2. Metanotum.
3. Metapleura.
4. Genitalia.

46(*a*). Insects infesting flour mills at Lyallpur.

KHAN A. RAHMAN *and* GURCHARAN SINGH SOHI, Lyallpur.

A regular examination of flour mills at Lyallpur was carried out during the summer of 1940 with a view to find out the insect pests of

stored grains found in them. From the flour deposits on the floor, windows, and ventilators *Latheticus oryzae* Waterh. and *Tribolium castaneum* Hbst. were collected; while *Attagenus piceus* was found in the sweepings containing flour, dirt and fibre and the different pests of stored grains, such as *Trogoderma Khapra* Arr., *Rhizopertha dominica* F., and *Laemophloeus pusillus* Schon. were met with round about the sieving and cleaning equipment. Adults of *Alphitobius laevigatus* F. were found in moist situations under the grain bags. But in big modern flour mills which are regularly washed and cleaned at least once a week, only stray specimens of *Tribolium castaneum* Hbst. were observed. This emphasizes the necessity of keeping the premises of mills free of flour, dirt deposits, etc.

Section X, Medical and Veterinary Research.

1. Physiological mutation in bacteria.

S. MAHDIHASSAN, Hyderabad-Deccan.

When a bacterium changes its typical morphological form it may be interpreted as due to contamination, polymorphy or mutation. A species of Mycobacterium has been studied and described which originally produced B-Carotin pigment. Later on, it gave rise to colonies of different grades of orange and yellow, indicating genuine mutations. It is believed this exceeds all previous records of colour mutations among bacteria. The paper will be followed by a demonstration illustrating the changes indicated.

2. Hypomagnesaemia in heifer calves.

S. N. RAY *and* K. GOVIND RAU, Mukteswar.

In examining the etiological factors for fainting 'fits' in some of our experimental heifer calves, the magnesium content of blood serum was found to give an average value of 1·2 mg. of magnesium per 100 c.c. of serum (range 0·7-1·7 mg. per 100 c.c.). This value is rather low when compared with the figures 2-3 mg. per 100 c.c. blood serum as found by Western workers. The concentration was further observed to diminish during the duration of these 'fits'. All the animals were getting wheat bhoosa as their roughage, and on changing the roughage to fresh hay, all the symptoms were found to have disappeared. The symptoms again returned on the substitution of wheat bhoosa as roughage. Feeding 4 ozs. of magnesium carbonate daily to one animal for 7 days raised the concentration of the mineral in its blood serum to the normal value of 2·3 mg. No direct evidence could, however, be established as to whether the magnesium deficiency was the actual cause of these fits. As the feed of these animals contained sufficient quantities of magnesium, the cause of the low concentration of serum magnesium is now being studied.

Section XI, Agriculture.

18(*a*). Reclamation of *Usar* and other unproductive lands in Bilada Farm.

BISHAN MANSINGH, Fatehpur.

Usar lands are made up of deep layers of stiff, heavy, poorly aerated clays, devoid of all humus and containing salts in injurious amounts. Some of the bad *Usar* lands are covered by brownish white substance, others by black incrustations.

No *Usar* land is well reclaimed unless it is opened up at least to a depth of 6 ft. the only cheap way of opening up the soil being to grow deep rooted hardy plants, such as Babool, calotropis, wild zizyphus, etc., but these vegetations would not thrive unless injurious salts which are always present in large amounts are first removed. This can be done by surrounding the land proposed for reclamation by strong embankments to hold water on it during rains or brought by canal. When the land is thus under water for a week or ten days the injurious salts would rise up to the surface. This saltish water should then be let out. This practice is to be repeated during rains as often as possible. This holding and letting out water also causes deep and wide cracks in the soil when it dries up, and thus opens the soil for the free action of the sun and air. Dried leaves, roots of vegetation and other organic matter brought down by water inside the embankment will provide humus to the land and make it permeable. If a slight quantity of slaked lime is added to the soil it will make it friable and fit for any vegetation to take root easily.

The reclamation of *Usar* land at Bilanda Farm was started in 1903 with a view to provide grazing ground for cattle. There was an additional gain that in course of time there developed a good Babool plantation. When 5 or 6 years later grazing in the Farm was regulated, self-grown Neem and Sheesham trees also appeared without any special effort. Up to 1934 Bilanda Farm was merely a good grazing ground covered only by Babool plantation. From 1917 to 1938 Babool trees worth Rs.24,000 and cattle chiefly calves worth Rs.2,000 were sold.

The cultivation of crops was taken up after 1934 when the whole area was surrounded by a ditch $10' \times 2'$ and the excavated earth formed a strong *Bandhi* on the outer three sides of the Farm. A plot of 40 acres was demarcated and was heavily manured both by decomposed and undecomposed compost manure, and cultivation of paddy was started on this whole area, which was a great success. Last year the yield of paddy reached 50 maunds per acre on some plots and good second crops of gram, wheat and barley were also obtained. Now *Jowar*, *Arhar* and *Coriander* are being grown successfully on this reclaimed land. Sugarcane is the only crop that has so far not done well.

In the year 1936 fruit culture was started in the Farm. There are now 250 good quality *Bers*, over 500 guava plants, 40 seed and 60 graft mango trees on the Farm,—all of these doing very well. Besides this there are over 500 self-grown Neem and over 50 Sheesham trees in addition to thousands of young Babool plants.

With so much cultivation and plantation the Farm provides fodder and grazing ground for a herd of over 100 cattle and Rs.100 worth *Tin* (thatching straw) every year.

18(*b*). Activation of the 'Blast Furnace Slag' of iron works for its employment to correct both alkalinity and acidity of soils.

K. Sitarama Iyer *and* S. Viswanatha Iyer, Trivandrum.

For the activation, the finely powdered slag is gradually stirred into an equal weight of diluted sulphuric acid of sp. gr. 1·2 (about 27% acid) when a vigorous action sets in. The mass gets cooked up to a thick paste which could be readily dried, smoothly ground up and cleanly bagged. The yield of the finished 'activated slag' is about 1·5 times that of the original slag employed. This simple process conveniently works with the blast furnace slag of both Jamshedpur and Bhadravati.

The material prepared from a sample of Jamshedpur slag has been analysed to remove from soil, per cwt. ploughed in, (1) alkalinity from alkaline soils equivalent to 27 lbs. of Na_2CO_3, (2) acidity from acid soils equivalent to about 25 lbs. of HCl, and also (3) to add, in due time, about 36 lbs. of clay to both acid and alkaline soils. The untreated slag does not

remove any alkalinity under similar conditions. The addition of clay to the soil (which would be secured when this activated slag is employed to remove its alkalinity but which would not be possible when gypsum is used instead) is of particular interest in case of soils like those of the Punjab-plains which are of relatively low clay-content. The iron works of North India can easily prepare, and also fully meet the demands of, this material from the Punjab, United Provinces, Bengal, Bihar and Deccan, while the Bhadravati works can similarly supply Mysore and South India.

About two tons per acre, applied as a soil-amendment and distributed in a period of four years may greatly ameliorate the defective soil. This material can profitably be employed in conjunction with small doses of such energy-materials as 'Molasses' wherever the same may be easily procurable.

43(*a*). Preliminary observations on the genetics of sugarcane.

P. C. RAHEJA, Tarnab.

Coefficient of variability, indices of conformity and percentage deviation from either of the parents both for leaf and cane characters were determined for the selfed progeny of Co. 214 and progeny of the cross Co. 213 × Co. 214. The coefficient of variability and indices of conformity both indicated that the progeny of Co. 214 selfed showed a very high degree of variability in the inheritance of measurable characters. In the progeny of the cross the alternative inheritance of characters was observed. Some characters showed greater degree of conformity to one parent and some to the other. In the cross cobybrids the characters, such as rind blush, pithy internal texture, and height of cane, behaved as dominants.

51(*a*). Physiological and Physico-Chemical studies on 4 F. Punjab American Cotton.

P. C. RAHEJA, Tarnab.

Comparative studies of respiration of leaves in situ, diurnal saturation deficit for study of water balance of plant, indices of foliar transpiring power, osmotic pressure determination, specific conductivity of tissue fluids, etc., were carried out at two-hour intervals, on an irrigated and unirrigated crop during the month of September at Lyallpur. The unirrigated crop was subject to incipient wilting during the day hours. The results are summarized as follows:—

1. In the irrigated fields the rate of respiratory activity was almost constant throughout the day except a slight increase in the morning hours. The unirrigated crop showed a considerable increase from 1·12 c.c. to 1·75 c.c. between 10 A.M. and 12 noon, followed subsequently by a regular depression in the metabolic activity of the plant up to 9 A.M. to regain its normal rate of functioning.

2. The indices of foliar transpiration of irrigated crop were higher than the unirrigated crop.

3. The value of the coefficient of correlation between the transpiration rate and the diurnal saturation deficit was higher (—0·62) in unirrigated crop compared to (0·50) in irrigated crop.

4. The osmotic values of the cell sap were considerably higher for the unirrigated compared to the irrigated crop. In consequence, the coefficient of correlation between leaf saturation deficit and osmotic values was much higher in the unirrigated crop (—0·93) than in the irrigated (—0·52).

5. The diurnal changes in electrical conductivity range were between 0·052 to 0·068 in the unirrigated crop as compared to 0·041 to 0·048 in the irrigated one. Therefore the value of the coefficient of correlation

between the electrical conductivity and freezing point of the cell sap, in the former case were higher (—0·95) than in the latter case.

57(*a*) Estimation of wheat yield by sampling.

A. K. MALLIK, V. SATAKOPAN *and* S. GOPAL RAO, Poona.

The paper indicates briefly the sampling problems involved in the estimate of crop outturn and describes an experiment of complete harvesting, in square yards, of a wheat field (4/10 of an acre in area) carried out at the Government Experimental Farm at Powerkheda, Hoshangabad, C.P., in 1939, with the kind co-operation of Dr. R. J. Kalamkar, Deputy Director of Agriculture, Jubbulpore. Sixteen hundred yields of grain were recorded and their frequency distribution has been examined. The variability of the crop as exhibited by the various sizes of units formed out of grouping the square yards is studied and it is found that a unit of 12 to 15 square yards will be most suitable for sampling operations on the crop. The optimum percentage for sampling the crop with 1 square yard as the unit is also discussed and a percentage of 12 to 15, if sampled at random, is found to yield about 80% of the information.

Section XII, Physiology.

18. Vitamin C (ascorbic acid) in rinderpest.

S. N. RAY *and* GOVIND RAU, Mukteswar.

Inoculation of multiple doses of rinderpest virus with small amounts of neutralized ascorbic acid is found to inactivate the virus totally. Administration of large amounts of ascorbic acid has no action on the course of the rinderpest disease in animals inoculated with the virus. Injections of ascorbic acid as adjunctions to anti-rinderpest serum do not increase the potency of the serum. Animals suffering from rinderpest but treated with ascorbic acid showed little or no ulceration in their mouths.

37. Diet of rice-eaters in the Godavari delta.

W. R. AYKROYD *and* B. G. KRISHNAN, Coonoor.

(*Nutrition Research Laboratories, I.R.F.A.*)

In the Madras Presidency beriberi, as a serious public health problem, is limited to the Northern Circars. It has already been shown (Aykroyd, Krishnan, Passmore and Sundararajan, 1940, *Ind. Med. Res. Memoir*, No. 32) that this can be explained by the fact that in this area the mass of the population prefers raw to parboiled rice, which even when highly milled usually contains over 1·5 parts per million of vitamin B_1. A diet survey carried out on a group of some 30 families in the Godavari delta showed that the diet consumed was similar in composition to that of poor rice-eaters elsewhere in the Madras Presidency, except that during the greater part of the year raw milled rice instead of parboiled rice is the main ingredient in the diet. The interesting fact was observed that for two or three months after the harvest in December-January, parboiled rice may be consumed because when stocks are low freshly harvested rice can be made immediately available for use by parboiling. Freshly harvested rice in the raw state cooks to a pasty consistency and usually raw rice is stored for several months before use. More cases of beriberi occur in the second half of the year than in the first half. This may be partly due to the use of parboiled rice in place of raw rice by a proportion of the poorer classes for a limited period during the earlier part of the year.

Section XIII, Psychology and Educational Science.

26(*a*). Observations and Experiments bearing on Dr. Rice's Hindustani Binet performance point scale tests.

V. G. JHINGRAN *and* KRISHNA KUMAR, Benares.

(1) Analysis of the test.

(*a*) Whole scale.
(*b*) Brief scale.
(*c*) Performance scale.

(2) The Brief scale consists of 10 questions which test attention, memory, observation, sense discrimination, form-perception, reasoning, moral sense, drawing and constructive ability, general knowledge and intelligence.

(3) The Whole scale consisting of 35 questions tests in addition to those tested by the Brief one, the aesthetic and poetical sense, power of defining concrete things and abstract ideas, arithmetical ability, power of conceptional reasoning and imagination.

(4) The Performance scale consists of nine questions and tests, excepting general knowledge and moral sense, all the abilities which the Brief Scale does.

(5) Defects of the tests.

(*a*) Distribution of questions of various types not uniform.
(*b*) Memory questions abound.
(*c*) A few tests do not possess discriminating power.

(6) Difficulties in administering the tests:—

(*a*) Difficulty about the language.
(*b*) Some of the questions are vague.
(*c*) Young children get tired and grow serious—^{r}Bp higher than ^{r}Wp.
(*d*) Grown-up children become light-hearted.

(7) Shortcomings of the Brief scale:—

(*a*) Memory marks 38 and even 44 out of a total of 82 marks.
(*b*) In a large number of cases the I.Q. was incalculable.

(8) Test not suitable to adults as a large number got marks above the maximum.

(9) Results based on some correlations were discussed.

11(*a*). Report on a questionnaire study of some sex problems among undergraduates.

B. KUPPUSWAMY, Mysore.

A list of questions on some problems relating to sex were given to a group of about eighty undergraduates in order to collect some facts concerning the source of their knowledge and the nature of their experience. It was found that sex information was sought very keenly when the boys were 11 to 14 years old: when they were in the Middle School classes. It was also found that the large majority of them got their first information through boys of their own age, culture and social status. Under 5% report that they got some information from their parents and only 28% report that they obtained some help from their teachers. Seventeen per cent of them report that they have had practical sex

experience, 42% report about sex play, while the remaining 41% report that they had experience of no type whatever.

41. The super-ego and social behaviour.

R. N. KAUL, Benares.

I. Is there an *antithesis between Freudian psycho-analysis and Marxian sociology?*
II. Is psycho-analysis nothing but a probing into the secret depths of the personality of the individual?
III. The Marxian 'Welt-anschaung' is that the individual is only a part of the social whole.
IV. The super-ego is the link between the individual and society.
V. The super-ego is the heir of the oedipus complex.
VI. Patriarchal dominance and the exploitation of the masses by the classes.
VII. *Poverty and Neurosis:* the twin diseases of modern bourgeois culture.
VIII. Freud and Marx: not antithetical, but complementary.

2. ERRATA AND ADDENDA

Proceedings of the Twenty-eighth Indian Science Congress

BENARES, 1941.

PART III—ABSTRACTS

(1) *Section of Chemistry.*

[Paper No. 71 on page 70 of Part III of the Proceedings of the 28th Session.]

In line 10—

Read

$$(c_+)_1+(c_-)_1 = \{(c_+)_2+(c_-)_2\} \cosh \frac{N^*E_mF}{RT}$$

instead of

$$(c_+)_2+(c_-)_1 = \{(c_+)_2+(c_-)_2\} \cosh \frac{N^{*\prime}E_mF}{RT}$$

In line 11—

Read 'Valences' *instead of* 'values'.

(2) *Section of Agriculture.*

[Paper No. 14 on page 249 of Part III of the Proceedings of the 28th Session.]

Read the following *instead of* the previous one—

Sheet Erosion on Gorat Soils (Gujarat).

C. C. SHAH *and* D. K. PATEL, Baroda.

White patches which are often seen on the alkali lands are to be seen at several places in Gujarat. Such patches which are to be seen on gorat soil have been fully investigated and it has been shown that the white material on the surface is nothing but leached sand formed under certain climatic conditions. The barrenness of such patches can be cured by deep cultivation and application of Farmyard Manure.

3. DISCUSSIONS

I. BOUNDARY VALUE PROBLEM IN DIFFERENTIAL EQUATIONS.

(Section of Mathematics and Statistics.)

PROF. M. R. SIDDIQI, Hyderabad-Deccan, presided.

1. REV. C. RACINE, Madras.

Some recent generalizations of the Dirichlet Problem.

The method of Fredholm to solve either the Dirichlet or the Neumann Problem in n dimensions has been extended by Giraud to equations of the elliptic type:

$$Fu \equiv \sum_{i,j}^{1\ldots n} a_{ij}(X)\frac{\partial^2 u}{\partial x_i \partial x_j} + \sum_{1}^{n} b_i(X)\frac{\partial u}{\partial x_i} + c(X)\,u = f(X),$$

where X stands for $x_1, x_2, \ldots, x_n$. The operator F generalizes the classical Laplacian.

G. Giraud has developed a first method, solving the Dirichlet or the Neumann problem for domains D in which the $a_{ij}(X)$'s, supposed continuous, have only small variations. This method is exactly similar to that of Fredholm. But in the potentials of the classical theory, to the distance

$$r^2(A, X) = \sum_{1}^{n} (x_i - a_i)^2$$

is substituted the expression

$$[L(A, X)]^2 = \sum_{1}^{n} A_{ij}(A)(x_i - a_i)(x_j - a_j).$$

Here A stands for $a_1, a_2, \ldots a_n$ and the A_{ij}'s are the minors of the a_{ij}'s in the determinant $| a_{ij} |$.

A second method has been proposed by Giraud to get rid of the restriction which the first one implicated. It consists of three steps:

(1) The coefficients a_{ij}, bi, and c are continued in the whole space. When X tends to infinity

$$\lim a_{ij} = \begin{cases} 0 & i \neq j \\ 1 & i = j \end{cases}$$

$$\lim b_j = 0$$

$$\text{and } c(X) < -g^2,$$

g being a numerical constant, outside of a bounded domain.

(2) A *principal elementary solution* is formed. It is a function $G(X, A)$, satisfying the equation

$$FG = 0,$$

except at $X = A$.

When $X \to A$ $\quad G(X, A) = O\left[L(X, A)^{\frac{2-n}{2}}\right].$

When $X \to \infty$, it tends to zero with its derivatives of the first order.

Such a function does not always exist, but Giraud has proved that if $C \leqslant O$ everywhere, it exists and is uniform.

(3) By substituting $G(X, A)$ to $r(X, A)$ in the classical integrals defining the potentials of simple and double distribution, or the potentials of domain, generalized potentials are defined, and the Fredholm method can easily be applied, the solution of the Dirichlet problem being given by a potential of double distribution, the Neumann problem being solved by a potential of simple distribution.

The domain D for which we solve these problems need no longer to be 'small', for *interior* and *exterior* problems can be solved by the potentials formed with the principal elementary solution and then it becomes easy to discuss the Fredholm equation of the problem and to prove that it has a solution.

J. Schauder has proposed a completely different method.

Let us consider, for instance, the same equation as above but with a second member depending on u: $Fu = f(X, u)$.

Schauder writes this equation

$$FU = f(X, u),$$
$$U = u$$

By depicting a certain function space for the function u, Schauder shows that the equations $FU = f(X, u)$ in D, and $U = \phi(X)$ on the boundary S of D define a functional operation

$$U(u).$$

In a great number of cases it is possible to extend to this transformation the celebrated theorem of the 'invariant point' proved by Bronwes in an n-space. The existence of this invariant point implicates manifestly the existence of the solution of the problem.

To a question put by Dr. Dhar, whether the case of singularities of the coefficients a_{ij}'s, b_i's and c had been considered by Giraud, the speaker answered that certain singularities had been considered, and the Dirichlet problem extended to that case. But these singularities are of a very special type. More general cases have not been studied except by M. Brelot, for the equation $\Delta u = c(X)u$, where Δ is the ordinary Laplacian.

2. PROF. M. R. SIDDIQI, Hyderabad-Deccan.

Some modern methods for the solution of Boundary Value Problems.

§1. The method of integral equations coupled with that of successive approximations has proved a powerful tool for the solution of linear as well as non-linear boundary value problems. Inspired by the classical work of Picard but employing the newly discovered theory of integral equations, Hilbert, Holmgren, Levi and others developed a method of Green's function for the solution of such problems.

In this method the important thing is the construction of the so-called Green's function which satisfies the differential equation, and which

possesses the required singularity. Later on Levi and Hilbert developed a 'method of parametrix'—a parametrix being a function which possesses the required singularity, but does not satisfy the differential equation. This method has the advantage that we need not assume the solubility of another differential equation before solving the given differential equation.

Thus, let us take the equation in the domain T:

$$(1)\qquad L[u] \equiv \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + a\frac{\partial u}{\partial x} + b\frac{\partial u}{\partial y} + cu = f(x, y),$$

and let us write

$$(2)\qquad \psi(x, y\,;\, \xi, \eta) = -\log \sqrt{(x-\xi)^2+(y-\eta)^2}.$$

It is required to determine a function $\rho(x, y)$ such that

$$(3)\qquad u(x, y) = w(x, y) + \iint_T \psi(x, y\,;\, \xi, \eta)\, \rho(\xi, \eta)\, d\xi\, d\eta$$

satisfies the differential equation (1), where w is an arbitrary function. From (3) and (1) we obtain

$$(4)\qquad \rho(x, y) = g(x, y) + \iint_T K(x, y\,;\, \xi, \eta)\, \rho(\xi, \eta)\, d\xi\, d\eta,$$

which is an integral equation for the determination of $\rho(x, y)$; the functions g and K are given by:

$$2\pi g(x, y) = L[w] - f,$$

$$2\pi K(x, y\,;\, \xi, \eta) = a\psi_x + b\psi_y + c\psi.$$

After an iteration, Fredholm's theory can be applied to (4). It is found that the integral equation (4) has a unique solution ρ, and consequently the differential equation (1) has a unique solution u in a sufficiently small domain T.

If, in particular, we take

$$w = -\log \gamma,\ \gamma^2 = (x-x_0)^2+(y-y_0)^2,$$

and write

$$(5)\qquad H(x, y\,;\, x_0, y_0) = -\log \gamma + \iint \psi(x, y\,;\, \xi, \eta)\, \rho(\xi, \eta)\, d\xi\, d\eta,$$

then $H(x, y;\, x_0, y_0)$ satisfies the differential equation (1) everywhere in T except at the point $x = x_0$, $y = y_0$. Moreover, since $H - \log \frac{1}{\gamma}$ is regular everywhere in T, the function $H(x, y\,;\, x_0, y_0)$ is the 'fundamental solution' of (1). When we know the fundamental solution, we can solve the boundary value problem in the usual way.

§2. The development of direct methods in the calculus of variations has furnished another method of attack on the boundary value problems. Formerly, the problem of differential equations was considered as simpler than the extreme m problem of the calculus of variations, and consequently the latter was solved with the help of Euler's differential equations. The relation between the two problems has now been reversed; the differential equations are considered as the Euler-equations of a variation problem which is solved directly. Dirichlet's problem is the first and most famous example of this method. After the pioneer work of Hilbert, the problem was considered by several authors, and a method of solving the boundary value problems with the help of the calculus of variations was developed.

We give here a short account of Courant's method for the first boundary value problem.

We wish to determine a solution $u(x, y)$ of

$$(1) \qquad L[u] \equiv \frac{1}{k_{(x,y)}}\left\{(pu_x)_x+(pu_y)_y-q^*u\right\} = -f(x, y),$$

$$q^* = q-a_x-b_y,$$

in the domain T with the boundary C, which takes the given values $g(x, y)$ on C.

In order to solve this boundary value problem we consider the following variation problem:

Of all the functions $\phi(x, y)$ which take the given values $g(x, y)$ on C, it is required to find a function $u(x, y)$ which makes the integral

$$(2) \qquad I[\phi] \equiv \iint_T \{p(\phi_x{}^2+\phi_y{}^2)+2(a\phi\phi_x+b\phi\phi_y)+q\phi^2-2kf\phi\}\,dx\,dy$$

a minimum.

It is easily verified that the Euler equation of (2) is the differential equation (1).

We can then prove the following two theorems in a direct manner.

Theorem 1. The boundary value problem can have at the most one solution.

Theorem 2. The solution of the boundary value problem is also the solution of the minimum problem.

But our problem here is the inverse one, viz. the direct solution of the minimum problem, and through it the solution of the boundary value problem. This inverse problem is solved with the help of 'Minimal sequences' which are defined as follows:

Let d be the lower limit of the integral $I[\phi]$ for the given condition. The sequence of functions $\phi_n(x, y)$ belonging to the space D°, and satisfying

$$(3) \qquad d_n = I[\phi_n] \to d \quad \text{as} \quad n \to \infty$$

is called a minimal sequence.

It is evident that such minimal sequences exist, but it is by no means evident how to obtain the required solution from such a minimal sequence by passing to the limit. The main question is therefore the construction of the limit function, which is done as follows:

Let σ denote the circle whose centre is (x_0, y_0) and whose radius is R, and let T_R denote a sub-domain of T for whose points (x, y) the circle σ lies in T. Let

$$\gamma^2 = (x-x_0)^2+(y-y_0)^2$$

and

$$(4) \qquad \psi_R(x, y) = \frac{1}{2\pi}\log\frac{\gamma}{R}+\frac{1}{4\pi}\left(1-\frac{\gamma^2}{R^2}\right), \qquad (\text{for } \gamma \leqslant R)$$

$$= 0. \qquad (\text{for } \gamma \geqslant R)$$

We write

$$(5) \qquad u_n(x_0, y_0) = \frac{1}{\pi R^2}\iint_{T_R} \phi_n\,dx\,dy+\iint_{T_R}(q^*\phi_n-kf)\phi_R\,dx\,dy.$$

It can be proved that $u_n(x_0, y_0)$ converges uniformly for all R, and all (x_0, y_0) in T_R to a continuous limit function u. This function u is therefore defined and continuous in the whole domain T and provides the required solution.

The second and third boundary value problems can also be solved in a similar manner.

§3. In 1914 and subsequent years, Lichtenstein applied Hilbert's theory of infinite bilinear and quadratic forms, and developed his well-known method of dealing with the boundary value problems by reducing them directly to equations in an infinite number of unknowns. We shall illustrate the method for one independent variable.

Let the given equation be in the interval $0 \leqslant x \leqslant \pi$:

$$\frac{d^2y}{dx^2}+q(x)y=f(x). \tag{1}$$

We wish to determine a solution $y(x)$ which is regular in $(0, \pi)$ and which satisfies the conditions:

$$y(0) = y(\pi) = 0. \tag{2}$$

With the help of an arbitrary, regular function $v(x)$ satisfying $v(0) = 0$, $v(\pi) = 0$, the problem (1), (2) is transformed to the following equivalent problem:

To find a function $y(x)$ which is regular in $(0, \pi)$ and which satisfies the equation

$$\int_0^\pi \left(\frac{dy}{dx}\frac{dv}{dx}-qyv+fv\right)dx = 0. \tag{3}$$

Writing

$$y(x) = \sum_{n=1}^{\infty} y_n \sin nx, \quad v(x) = \sum_{n=1}^{\infty} v_n \sin nx, \tag{4}$$

$$Y_n = ny_n, \quad V_n = nv_n,$$

we obtain from (3):

$$-\sum_{n=1}^{\infty} Y_n V_n + \sum_{m,n}^{1\ldots\infty} q_{mn} Y_m V_n = \sum_{n=1}^{\infty} f_n V_n, \tag{5}$$

where

$$q_{mn} = \frac{2}{\pi_{mn}}\int_0^\pi q \sin mx \sin nx\, dx,$$

$$f_n = \frac{2}{\pi_n}\int_0^\pi f \sin nx\, dx.$$

The equation (5) holds in particular for all systems of values:

$$V_1 = 0,\ V_2 = 0, \ldots, V_{n-1} = 0,\ V_n = 1,\ V_{n+1} = 0, \ldots. \tag{6}$$

$$(n = 1, 2, \ldots).$$

Hence we obtain the infinite system of Hilbertian linear equations:

$$\sum (q_{mn}-\delta_{mn}) Y_n = f_m, \qquad (m = 1, 2, \ldots \infty), \tag{7}$$

where

$$\delta_{mn} = 0 \qquad (m \neq n)$$
$$= 1 \qquad (m = n).$$

A solution Y_1, Y_2, ... of the infinite system (7) will provide us with the function

$$(8) \qquad y(x) = \sum_{1=n}^{\infty} \frac{Y_n}{n} \sin nx$$

satisfying the relation (5), and consequently the differential equation (1) and the conditions (2).

Lichtenstein has extended this method in an analogous manner to the equation

$$(pu_x)_x + (pu_y)_y + (q + \lambda k)u = f(x, y),$$

for various boundary conditions.

3. Mr. S. Minakshisundaram, Madras.

Application of Functional Calculus to Boundary Value Problems.

The methods of functional calculus are very useful in answering linear and non-linear problems in differential and integral equations. This was first observed by Birkhoff and Kellogg and later systematically developed by J. Schander and J. Leray. The lecture is an exposition of the methods of these authors and their applications to boundary value problems.

4. Prof. N. M. Basu, Dacca.

Prof. N. M. Basu referred to the work of Tonneli and spoke on the significance of the semi-continuous character of the Functional which has to be minimized in the treatment of boundary value problems by the direct method of the calculus of variations. He then referred to his own work embodied in two papers, namely (1) '*On an Application of the New Methods of the Calculus of Variations to some Problems in the Theory of Elasticity*', Phil. Mag. X, 1930, pp. 886–896, and (2) '*On the Torsion Problem of the Theory of Elasticity*', Phil. Mag. X, 1930, pp. 896–904, wherein it was shown how the expressions for the required functions could be obtained to any desired degree of approximation as series in polynomials and therefore very suitable for numerical computations. He also pointed out that the powerfulness of the method was indeed very great as evidenced by the fact that the torsion function for a cylinder with square section, calculated by this method, yielded, even when only two terms of the series were calculated, a value for the twisting couple with an error less than 1 in 750 and differing from the value obtained by Saint Venant by less than 1 in 11,000.

5. Dr. S. C. Dhar, Nagpur.

Dr. Dhar spoke on the operational and other methods on the solution of boundary value problems.

II. DIOPHANTINE PROBLEM.

(*Section of Mathematics and Statistics.*)

PROF. M. R. SIDDIQI, Hyderabad-Deccan, presided.

DR. T. VIJAYARAGHAVAN, Dacca, opened the discussion.

Problems of Diophantine Analysis.

Diophantine analysis is one of the oldest branches of mathematics though it is named after Diophantus, a Greek mathematician of the third century A.D. The vastness of the subject will be realized by any one who even glances at the preface, table of contents, author index and the subject index of Vol. II of the *History of the Theory of Numbers* by L. E. Dickson.* The subject-matter of Vol. II of the *History* is *Diophantine Analysis*, and the volume contains reports on upwards of five thousand writings. Since the publication of the *History* several hundreds of papers have been published on the subject, and these figures are indeed very impressive for any branch of mathematics.

The subject owes its origin partly to the fascination that curious properties of integers have for the human mind and chiefly to the crisis in Greek mathematics due to the discovery of the existence of irrational numbers. A result such as that the triangle whose sides are 13, 14 and 15 has the area 84 might not have seemed worthy of much notice before it was realized that if we take a triangle with integral sides it is very probable that the area will be an irrational number. Again, but for the discovery of irrational numbers it is unlikely that the question would have been asked whether or not there is a rational right triangle† whose area is equal to a given rational number, say, for instance, unity? Most of the problems tackled by Diophantus could not have arisen except in the context of the discovery of the existence of irrational numbers. My chief object here is to mention a number of interesting results to illustrate a fraction of the scope of the subject.

1. It was known to Pythagoras (570–501 B.C.) that the sum of the first n odd integers is equal to the square of n.

2. Nicomachus (about 100 A.D.) observed that $1 = 1^3$, $3+5 = 2^3$, $7+9+11 = 3^3$, $13+15+17+19 = 4^3$ and so on.

3. C. G. Bachet (Diophanti Alex. Arith., 1621) combined the above results to obtain the result that

$$1^3+2^3+\ldots+n^3 = (1+2+3+\ldots+n)^2.$$

4. A complete parametric solution for the sides of a rational right triangle is given by

$$2\alpha mn,\ \alpha(m^2-n^2),\ \alpha(m^2+n^2)$$

where α, m and n are positive rational numbers and $m>n$. This solution was known to Euclid.

If α, m and n are restricted to be integers then we get all the integral solutions; if we further suppose that m and n are prime to each other and

* Carnegie Institution of Washington, Publication No. 256, Vol. II.

† A triangle one of whose angles is a right angle, and whose three sides are rational numbers is a rational right triangle. Similarly we define an integral right triangle. The sides containing the right angle are referred to as the legs of the triangle.

that one of them is even then we get all the integral solutions without duplication.

5. L. E. Dickson obtained in 1894 a complete solution in the form $r+s$, $r+t$, $r+s+t$ where $r^2 = 2st$.

6. Fermat (seventeenth century) noted that if a, b, c are the sides of a right triangle then $2a+b+2c$, $a+2b+2c$, $2a+2b+3c$ are the sides of another right triangle and that the difference between the legs is the same in each case.* Starting from the right triangle (3, 4, 5) and repeatedly applying the transformation given above, we get the sequence of triangles

$$(3, 4, 5), (20, 21, 29), (119, 120, 169), (696, 697, 985).$$

It is known that this sequence contains all such integral right triangles. If u_1, u_2, u_3 ... be the sequence of the lengths of the smaller legs, viz. 3, 20, 119, 696, ... and v_1, v_2, v_3, ... be the sequence of the lengths of the hypotenuses then

$$\left.\begin{aligned} v_{n+2} &= 6v_{n+1} - v_n \\ u_{n+2} &= 6u_{n+1} - u_n + 2 \end{aligned}\right\} (n = 1, 2, 3, \ldots.)$$

7. Starting from the three right triangles (5, 12, 13), (8, 15, 17) and (21, 28, 35) and by applying repeatedly Fermat's transformation, we obtain all the integral right triangles whose legs differ by 7. Similar remarks apply when the legs differ by any given integer d.

8. Diophantus (V, 8) noted that the three right triangles (42, 40, 58), (70, 24, 74), (112, 15, 113) have the same area 840. If $a^2+b^2+ab = c^2$ then the triangles formed from (c, a), (c, b) and $(c, a+b)$ have the same area [the triangle (x, y, z) is said to be formed from (m, n) if $x = 2mn$, $y = m^2-n^2$, $z = m^2+n^2$]. The triangles given by Diophantus correspond to $a = 3$, $b = 5$, $c = 7$.

The right triangles (a, b, h) and

$$\left(\frac{2abh}{2b^2-h^2}, \frac{2b^2-h^2}{2h}, \frac{h^4+4b^2h^2-4b^4}{2h(2b^2-h^2)}\right)$$

have the same area. The process can be repeated to obtain any number of such triangles.

C. Tweedie [*Proc. Edinb. Math. Soc.*, 24, (1905-6), 7–19] treated the problem of obtaining all rational right triangles of area A. It leads to a discussion of the rational points on the cubic curve

$$x(1-x^2) = Ay^2.$$

9. Diophantus (VI, 18) found a rational right triangle with the bisector of one acute angle rational. The triangle (28, 96, 100) has one such bisector equal to 35.

C. G. Bachet in his commentary on the preceding noted that no rational right triangle has a rational bisector of the right angle.

10. Heron of Alexandria (first century B.C.) gave the well-known formula for the area of a triangle in terms of the sides and noted that when the sides are 13, 14, 15 the area is 84. A triangle with rational sides and rational area is called a rational triangle or a Heron triangle.

Brahmagupta (born 598 A.D.) noted that by the juxtaposition of two rational right triangles with a common leg x we obtain a rational triangle. Every rational triangle can be obtained in this way.

11. There are an infinity of Heron triangles whose sides are consecutive integers; they are precisely (3, 4, 5), (13, 14, 15), (51, 52, 53), (193, 194, 195), ... If u_1, u_2, u_3, ... denote the sequence of the

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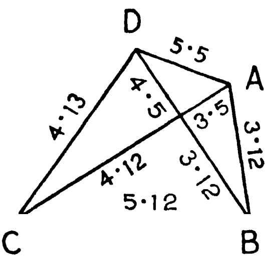
* Denoting the second triangle by (A, B, C) we see that (a, b, c) is the same as $(2A+B-2C, A+2B-2C, 3C-2A-2B)$.

lengths of the middle sides of the above sequence of triangles, and $\frac{1}{2}u_n p_n$ the area of the nth triangle then

$$\left.\begin{aligned} u_{n+2} &= 4u_{n+1} - u_n \\ p_{n+2} &= 4p_{n+1} - p_n \end{aligned}\right\} (n = 1, 2, 3, \ldots .)$$

12. A rational quadrilateral is one whose sides, diagonals and area are expressed by rational numbers.

Brahmagupta—who, by the way, discovered the formula for the area of a cyclic quadrilateral in terms of the sides, a generalization of Heron's formula for the area of a triangle *—stated that 'the legs of two right triangles multiplied reciprocally by the hypotenuses give the four sides of a trapezium'. This riddle concerns the construction of a rational quadrilateral, and was explained by Bhaskara (born 1114), his commentator Ganesa (1545 A.D.), M. Chasles, and E. E. Kummer (*Jour. für Math.*, **37**, 1848, 1–20). The illustration given by Bhaskara is as follows:—



We start from two rational right triangles such that the hypotenuse of one is equal to a leg of the other. The quadrilateral is obtained by a suitable juxtaposition of the four triangles obtained by multiplying the sides of each given triangle by the base and perpendicular of the other. For a correct exposition of the method used by Brahmagupta, Kummer's paper or Vol. II of Dickson's *History* (p. 217) may be consulted.

13. Paul Halcke (Hamburg, 1719) gave the solution

$$x = 44,\ y = 240,\ z = 117 \text{ (sides)}$$

$$x = 267,\ y = 125,\ z = 244 \text{ (diagonals)}$$

of a rectangular parallelepiped whose edges and diagonals of faces are all rational. The problem that we have by adding the condition that also a diagonal of the solid shall be rational is believed to be impossible. A. Mukhopadhyaya [*Math. Quest. Educ. Times*, **41**, (1884), 60] proved it impossible if the edges be relatively prime integers.

14. The equation $ax^2+bx+c = y^2$ turns up in connection with a very large number of problems. Diophantus was led to such an equation in at least forty of his problems. The problems in 6, 7 and 11 above lead to the solution in integers of the equation $ax^2+c = y^2$.

As shown by Diophantus it is not very difficult to obtain the complete rational solution of $ax^2+1 = y^2$; we write $y = mx+1$, and solving the resulting equation ($ax^2 = m^2x^2+2mx$) we get

$$x = \frac{2m}{a-m^2}, \qquad y = \frac{m^2+a}{a-m^2}.$$

* A triangle may be looked upon as a limiting case of a cyclic quadrilateral.

To obtain the solution in integers is a problem of different calibre. Dickson (p. xi of the preface of Vol. II of the *History*) writes: 'It is a remarkable fact that the Hindu Brahmagupta in the seventh century gave a tentative method of solving $ax^2+c = y^2$ in integers, which is a far more difficult problem than its solution in rational numbers. His method was explained more clearly by the Hindu Bhaskara in the twelfth century'.

15. We now go back to a problem mentioned earlier. What rational numbers can be the area of a rational right triangle? To answer this question it will suffice to determine what integers can be the area of a rational right triangle? In this connection it may be remarked that the answer to this question turns out to be the same as the answer to the question, which integers are congruent numbers? [A number $k \neq 0$ is said to be a congruent number if there exist rational numbers x, y and z such that their squares are in arithmetical progression with the common difference k. It is known that no four squares can be in arithmetical progression. The story of congruent numbers is a long one beginning with Diophantus. This type was the chief subject of two Arabic manuscripts of the tenth century.]

It can easily be deduced from the results mentioned in 4 that an integer A can be the area of a rational right triangle if and only if it is of the form $(a^4-b^4)/c^2$ where a, b and c are positive integers. This solution of the problem is not satisfactory, for, in general, it is by no means easy to determine whether or not a given integer can be expressed in the form $(a^4-b^4)/c^2$. For more than ten centuries it was a well-known unsolved problem whether or not $(a^4-b^4)/c^2$ can be equal to unity. Fermat proved its impossibility and thereby also proved that the equation $\alpha^4+\beta^4 = \gamma^4$ cannot be solved in positive integers. Fermat's result is, of course, equivalent to proving that no square number can be a congruent number.

Not much seems to be known about the numbers of the form $(a^4-b^4)/c^2$. Leonardo Pisano (thirteenth century) noted that if three of the four numbers a, b, $a+b$, $a-b$ be squares then the fourth number is a congruent number. Thus, since 16, 9 and $16+9$ are squares it follows that $16-9 = 7$ is a congruent number. It is known that the only congruent numbers < 20 are 5, 6, 7, 13, 14 and 15. It was proved by Genocchi (*Memorie di Mat. e Fis. Soc. Ital. Sc.*, (3), **4**, (1882), No. 3) that the following numbers are not congruent: *a prime $8k+3$ or the product of two such primes; the double of a prime $8k+5$ or the double of the product of two such primes.*

16. A similar problem concerns the set of integers that can be expressed as a sum of two rational cubes a^3 and b^3 where $ab \neq 0$; ab is not necessarily positive. [This problem arises because it is known that every rational number can be expressed as a sum of three rational cubes. It is known that every positive rational number can be expressed as a sum of four positive ratonal cubes.] It was observed by E. Lucas that a number is a sum of two cubes if and only if it is of the form $ab(a+b)/c^3$ where a, b and c are positive integers. In general it is not easy to determine if a given number is or is not of this form. It is known that the numbers 2, 6, 7, 9, 12, 13, 15, 16, 17, 18, 19, 22, 26, 28, 30 . . . . are of this form and that 1, 3, 4, 5, 8, 10, 11, 14, 21, 23, 24, 25, 27, 29, . . . are not of this form. [Since 1 is not of this form it follows that a cube is not a sum of two cubes.] The results that are known give a picture which is far from complete. I mention here some of the known results. If p, p_1 are primes $18l+5$ and q, q_1 primes $18k+11$ then $A \neq x^3+y^3$ whenever $A =$ $p, q, 2p, 4q, 5q, 9p, 9q, 25p, pq, p^2, q^2, 2q^2, 4p^2, 5p^2, 9q^2, 9q^2, 25q^2, pp_1^2,$ qq_1^2, p^2q^2. If $v = 6m+1$ is a prime so that $v = A^2+3B^2$ then $v = x^3+y^3$ if at least one of the numbers $2A$, $3B+A$, $3B-A$, $\frac{2}{3}B$, $\frac{1}{3}(A+B)$, $\frac{1}{3}(A-B)$ is a cube.

If $A = 2r^3 = x^3+y^3 \neq 0$ then $x = y = r$. This result is due to Euler. Fermat had shown earlier that if $A = x^3+y^3$, $x \neq y$ then A is a

sum of two cubes in an infinity of ways. J. Prestet employed Fermat's process to get the identity

$$x^3+y^3 = \left\{\frac{x(2y^3+2^3)}{x^3-y^3}\right\}^3 + \left\{\frac{y(2x^3+y^3)}{x^3-y^3}\right\}^3.$$

17. Another problem with similar features is to determine all non-square positive integers A for which the equation

$$Ax^2 = y^2+1$$

can be solved in integers x, y. It is known that there exist solutions if and only if the number of elements in the periodic part of the simple continued fraction of $\sqrt{A}$ is odd. This is indeed a very satisfactory answer, but when we seek for results similar to those mentioned in 15 and 16 we find that though many results are known still there is scope for much new discovery. I mention a few known results. The equation has solution if $A = 4m+1 =$ prime; also if $A = 2p^{\alpha}$, $2p^{2\alpha+1}q^{2\beta+1}$, $2p^{2\alpha}q^{2\beta}\ldots\ldots t^{2\sigma}$, where $p, q, \ldots t$ are primes $8k+5$; also if $A = 2r$, where r is a prime, $r = 16m+9$, and d is divisible by 8 where d is such that $r = c^2+2d^2$. The equation has no solution if A is divisible by 4 or by a prime $4m+3$ or if $A = 2p$ and d is not divisible by 8 where p is prime, $p = 8m+1$, $p = c^2+2d^2$.

18. It was mentioned in the course of 15 that Fermat proved that the equation

$$a^4+b^4 = c^2$$

has no solution in positive integers. But the sum of three biquadrates may be a square. Diophantus gave the example

$$12^4+15^4+20^4 = 481^4.$$

Euler tried in vain to solve the equation

$$a^4+b^4+c^4+d^4 = e^4.$$

Up till now only one solution of this equation is known. R. Norrie [University of St. Andrews' 500th Anniversary Memorial Volume, Edinburgh, (1911) 89] found in confirmation of Euler's conjecture

$$30^4+120^4+272^4+315^4 = 353^4,$$

by a series of special assumptions which lead to this single result. Euler had stated: 'It has seemed to many geometers that this theorem ($x^n+y^n \neq z^n$, $xyz \neq 0$, $n>2$) may be generalized. Just as there do not exist cubes whose sum or difference is a cube, it is impossible to exhibit three biquadrates whose sum is a biquadrate, but that at least four biquadrates are needed if their sum is to be a biquadrate ..... In the same manner it would seem to be impossible to exhibit four fifth powers whose sum is a fifth power, and similarly for higher powers'.

The general solution of

$$A^3+B^3+C^3 = D^3$$

was given by Euler. A few numerical cases are

$3^3+4^3+5^3 = 6^3$, $1^3+6^3+8^3 = 9^3$, $7^3+14^3+17^3 = 20^3$, $11^3+15^3+27^3 = 29^3$.

S. Sastry (*Journal of the London Math. Soc.*, 9, (1934), 242–246) gave an identity which yields an infinity of fifth powers which are sums of five fifth powers. In particular,

$$107^5 = 7^5+43^5+57^5+80^5+100^5$$
$$17516^5 = 709^5+5366^5+11441^5+14175^5+15435^5.$$

19. Finally, I shall mention a few results on Diophantine approximations.

It is known that if A is a non-square positive integer than the so-called Pell equation

$$x^2 - Ay^2 = 1$$

has an infinity of solutions in positive integers.* It is easy to verify that x/y is then such an approximation to $\sqrt{A}$ that

$$\left| \sqrt{A} - \frac{x}{y} \right| < \frac{1}{2\sqrt{A}y2}.$$

It is known that if θ is any irrational number then there exist an infinity of approximations x/y such that

$$\left| \theta - \frac{x}{y} \right| < \frac{1}{\sqrt{5}y^2}$$

and that if θ is not a quadratic surd then the $\sqrt{5}$ in the above inequality can be replaced by any positive number less than 3.

One of the well-known unsolved problems of Diophantine approximations is as follows: Suppose that $f(r)$ denotes the number of lattice points within the circle $x^2 + y^2 = r$. It seems plausible that $f(r)$ will be very nearly equal to πr which is the area of the circle, and indeed so it is. The problem is to estimate $f(r) - \pi r$. It is believed that however small a positive number ϵ may be the limit, as $r \to \infty$, of

$$\frac{f(r) - \pi(r)}{r^{\frac{1}{4}+\epsilon}}$$

is equal to zero. This result is still unproved.

Finally, I should like to say that any one who finds Diophantine Analysis to be an interesting subject will find Dickson's *History* a source of endless delight.

2. DR. S. S. PILLAI, Annamalainagar.

He spoke on 'Exponential Diophantine Equations'.

3. DR. S. CHOWLA, Lahore.

He spoke on the 'Additive Theory of Numbers'.

4. PROF. N. M. BASU, Dacca.

He gave an account of the work of Tchacaloff and Karanicoloff recently published (*Comptes Rendus*, t. 210, 1940) wherein the authors obtained *all* rational solutions of the Diophantine Equation

$$Ax^m + By^n = Z^p,$$

where A and B are rational numbers and m, n, p are any set of co-prime integers. He then explained the generalization of the above result

* Dickson (Vol. II of the *History*, p. 341) writes: There appeared in India and Greece as early as 400 B.C. approximations a/b to $\sqrt{2}$ such that $a^2 - 2b^2 = 1$, and similarly for other square roots, the derivation of successive approximations being in effect a method of solving the Pell equation. For example, Baudhayana, the Hindu author of the oldest of the works, *Sulva-sutras*, gave the approximations 17/12 and 577/408 to $\sqrt{2}$. Note that $\frac{17}{12} + \frac{-1}{2.27.12} = \frac{577}{408}$, $17^2 - 2.12^2 = 1$, $577^2 - 2.408^2 = 1$.

obtained by himself, namely, the general solution in rational numbers of the equation

$$A_1 x_1^{m_1} + A_2 x_2^{m_2} + \dots + A_k x_k^{m_k} = Z^p,$$

where A_1, $A_2, \dots A_k$ are rational numbers, $m_i = gn_i$, $i = 1, 2, \dots k$, $g \geqq 1$ and $n_1, n_2, \dots n_k$, p are any set of co-prime integers. He also referred to the further generalization obtained by Dr. T. Vijayaraghavan who obtained all rational solutions of the above equation where $(m_1, m_2, m_3 \dots m_k, p) = 1$.

Closing the discussion Dr. T. Vijayaraghavan spoke on 'Some problems of Diophantine approximations' as follows:—

Let θ be a real number, $\theta \geq 1$, and $G(\theta)$ the set of limit points of the fractional parts of θ^n $(n = 1, 2, 3, \dots)$.

Theorem:—*If θ is algebraic, and $G(\theta)$ does not consist of an infinity of points then θ is an algebraic integer, and every one of the algebraic conjugates of θ, other than θ itself, lies within the unit circle.*

The converse is, of course, true. In fact, it is the converse that suggested the above theorem. It is probable that in the above theorem the condition that θ is algebraic is superfluous. One reason for thinking so is the following theorem:—

The set of numbers θ for which $G(\theta)$ does not consist of an infinity of points is an enumerable set.

It is known that the set of numbers θ for which $G(\theta)$ does not consist of the entire unit interval is of Lebesgue measure zero. Indeed the same remark applies to the set of numbers θ for which the distribution of the points θ_n, when θ_n is the fractional part of θ^n, is not 'uniform' in the unit interval. Against this background the following theorem seems worth stating:—

Let $d_1, d_2, d_3, \dots$ be a sequence of intervals contained in the unit interval, and let the lower bound of the lengths of these intervals be positive. A number θ is said to belong to S if θ_n falls in d_n for $n = 1, 2, 3, \dots$. We have then that the set S has the power of the continuum.

III. THEORY OF THE STRUCTURE OF SOLIDS.

(*Sections of Mathematics and Statistics, and Physics.*)

PROF. K. S. KRISHNAN, Calcutta, presided and opened the discussion.

2. PROF. S. BHAGAVANTAM, Waltair.

3. PROF. B. B. RAY, Calcutta.

4. DR. K. BANERJEE, Dacca.

Application of the Fourier Analysis Method to the Determination of Crystal Structure.

A crystal consists of a periodic structure in three dimensions and hence the density of matter responsible for X-ray scattering may be represented by a three-dimensional Fourier summation.

$$\rho(x, y, z) = \sum_{-\infty}^{\infty}\sum_{-\infty}^{\infty}\sum_{-\infty}^{\infty} A(hkl) \cos \left\{ 2\pi \left(\frac{hx}{a} + \frac{ky}{b} + \frac{lz}{c} \right) + \phi_{hkl} \right\}.$$

If $F(hkl)$ represents the structure factor for reflection from (hkl) plane, it was shown by W. H. Braggs that

$$A(hkl) = \frac{1}{V} F(hkl)$$

where V is the volume of the unit cell.

A more practicable series has been developed by W. L. Bragg more recently in which the density of scattering matter projected on a crystallographic plane is given by

$$\rho(y, z) = \frac{1}{\alpha} \sum_{-\infty}^{\infty} \sum_{-\infty}^{\infty} F(okl) \cos \left\{ 2\pi \left(\frac{ky}{b} + \frac{lz}{c} \right) + \phi_{okl} \right\}$$

where α is the area of the face of the unit cell on which the electron density is projected. For centrosymmetrical crystals, however,

$$\phi_{okl} = 0 \text{ or } \pi$$

Thus the Fourier Summation Method resolves into the determination of the structure factors and the phase constants. The structure factors may be determined from X-ray diffraction intensities as expressions have been deduced by Darwin, Ewald and Compton giving the relations between integrated intensities of reflections and structure factors. The integrated intensities are determined either by the ionization method or by the photographic method. In the former method the slit of the ionization chamber is made sufficiently wide as to receive the whole reflected beam and the crystal is slowly rotated about the position of reflection. The area under the ionization curve thus obtained gives the integrated intensity. In the photographic method, the blackening due to reflection is to be compared with a standard which gives the relation between exposure and blackening. Robinson devised a balancing method in which light from two sources pass through the diffraction spot and a so-called standard wedge (in which exposure is proportional to the distance from a certain origin) and falls on two photoelectric cells. The currents through the photoelectric cells amplified by valves are balanced against each other by pushing forward or drawing back the standard wedge and the balancing is indicated by a galvanometer. The distances moved by the wedge are mechanically integrated. A graphical method is being used at the author's laboratory at Dacca, the ordinates on the photometric curve obtained from a Zeiss microphotometer at points at small intervals along abscissa are converted into intensity values by comparison with the photometric curve of the standard wedge and added.

From measurement of the integrated intensities we obtain the squares of the structure factors from which we obtain their numerical values. Thus the phase terms remain unknown. In centrosymmetrical crystals only the signs of the terms are to be determined as the phase may be either 0 or π. The method that has been commonly used is the method of trial and error. In this method preliminary determination of structure is effected by trial. Structure factors for reflections from the different planes are calculated by assuming various arrangements of the atoms in the unit cell which are feasible geometrically and conform to the chemical formulae. When a rough agreement is obtained between the measured and the calculated structure factors, the Fourier summation is carried out by using the signs of the calculated structure factors with the values of the measured ones. Examples are afforded by the determinations of the structures of naphthalene and anthracene by Robertson by the Fourier analysis method with the help of the preliminary determinations of the present author.

Direct determination of the signs of terms has been attempted more recently. The first of these is an algebraic method developed by the author. In this method equations are set out between the co-ordinate positions of the atoms and structure factors. Since the number of measured structure factors are usually very large, the number of equations that can be set up will be greater than the number of unknown parameters. Hence the latter may be eliminated and equations are obtained only between the structure factors. So a self-consistent set of signs may be obtained. Another method of the determination of the signs of the Fourier terms has been developed by A. L. Patterson. He showed that if we take a Fourier series in which the squares of the structure factors occur as

$$A_{yz} = \sum_{-\infty}^{\infty} \sum_{-\infty}^{\infty} F^2(okl) \cos 2\pi\left(\frac{ky}{b}+\frac{lz}{c}\right),$$

then the lines joining the origin of co-ordinates to the maxima of the plot of these Fourier summations represent vectorially the interatomic distances as projected on the *YZ* plane. Thus M. Ganguly and the author have determined the structure of metadinitrobenzene by correlating the positions of the different maxima with the interatomic distances in this substance and thus a preliminary determination of atomic arrangements has been possible.

Though there is always some elements of trial in the determination of the signs of the terms in the Fourier summation, the solution when once obtained is unique. This is very nicely exemplified by the structure determination of anthraquinone. The Fourier summation for this crystal was carried out on the basis of a wrong crystal system. This was believed by earlier crystallographers to be orthorhombic but on carrying out the Fourier summation it definitely showed a lower order of symmetry. So two rotation photographs were taken along two diagonals and the crystal system was confirmed to be monoclinic.

5. Prof. N. N. Sen, Sibpur.

The Microstructure of Metals.

Two aspects of the structure of metals should be distinguished. One is its crystal structure, i.e. the arrangement of the atoms in the unit cell of the space lattice as determined by the method of X-ray analysis and the other is its microstructure by which is meant the description of the size, shape and disposition of the different crystalline constituents present in the metal. The crystals of metals as a rule are very small—their dimensions usually varying between 1/10 and 1/1000 mm. and their presence is revealed by examining a specimen under a microscope after grinding, polishing and etching with suitable reagents.

The crystal structure of majority of metals is rather simple and they have either body centred cubic, face centred cubic or close packed hexagonal space lattices. When solid solutions are formed, the basic structure of the unit cell in the crystal remains unaltered. The solute metal atoms either replace the atoms of the solvent metal in the space lattice or they take up their position between the interstices of the lattice atoms. But when one metal combines with another metal, the crystal structure of the compound undergoes a fundamental change and assumes a more complex form.

In three important respects crystals of metals differ from crystals of other substances. Firstly, they are opaque to light and are therefore examined in reflected light. Secondly, they are not bound by plane (crystallographic) surfaces having definite interfacial angles between

them, thus lacking in regular geometrical shape commonly associated with crystals. Thirdly, when they are subjected to mechanical stress beyond their elastic limit, they do not suddenly rupture but continue to deform by slipping along certain crystallographic planes. It is rather fortunate that the metals possess the last two characteristics because the mechanical properties of metals for which they are valued largely depend on them.

In the molten state a mixture of metals is a mixture of their atoms. But when they are cooled, they are deposited as crystals of pure metals, solid solutions inter-metallic compounds or some combination of these. These are known as the constituents of the alloy and their nature and relative proportions are obtained by reference to their constitutional diagrams which represent the change of constitution with change of composition and temperature. It has already been pointed out that the size, shape and arrangement of these constituents in a sample of metal constitute the microstructure of the metal. It has been demonstrated that the properties of a metal are closely related to its structure. The microstructure can be changed primarily by altering the composition of the metal. Secondarily a constitutional and consequently a structural change can be brought about by suitable heat treatment. On the other hand, the size and mutual disposition of the constituents can be altered by mechanical treatment without producing any change in the constitution. It is thus seen that any alteration in any of the three major facters, viz. (1) composition, (2) heat treatment, and (3) mechanical treatment can influence the properties of a metal by producing definite changes in the microstructure of the metal.

Some typical photo-micrographs were then shown to indicate the characteristic features of microstructures of metals and to illustrate how different factors modify them.

IV. MATHEMATICAL THEORY OF STATISTICS.

(Section of Mathematics and Statistics, in co-operation with the Indian Statistical Conference.)

DR. C. W. B. NORMAND, Poona, presided.

Mr. S. N. Roy started a discussion on the 'problems of discrimination and classification'. Confining himself primarily to univariate normal populations he explained how the usual tests of significance '*t*' and '*z*' served to discriminate between two or many populations in respect of both the parameters, how on the non-null hypothesis one could define similar functions of the populations parameters to serve as a suitable measure of the difference between the populations in respect of the parameters, and how the sampling distributions of '*t*' and '*z*' on the non-null hypothesis could give us some idea of the divergence between the populations, thus leading to their classification. He then briefly referred to some of the extensions of these concepts and tools to the case of multivariate normal populations.

Prof. P. C. Mahalanobis, who spoke next, dwelt on the historical development of the tools of classification and how the method for the classification in respect of the means had a certain analogy with the line element in the gravitational theory of relativity.

V. THEORY OF STELLAR STRUCTURE.

(Sections of Physics, and Mathematics and Statistics.)

PROF. P. N. GHOSH, Calcutta, presided.

1. DR. R. C. MAJUMDAR, Calcutta.

Hertzsprung-Russell Diagram and the Problem of Stellar Structure.

Astronomical observations allow us to determine three important physical characteristics of a star, the mass, the radius and the luminosity (the total energy in ergs radiated per second) usually denoted by the symbols M, R and L respectively. The masses of the stars are determined by measuring the acceleration produced in them by the neighbouring stars and have so far been successfully determined only for the binary stars. The luminosity is found out from the apparent brightness and the radius for large stars are measured directly by Michelson's interferometer. But for ordinary stars the radius is determined by roundabout methods. Since each colour of light has a special temperature associated with it, the surface temperature is first measured from an analysis of the distribution of different colours of light in the spectrum of the star and then knowing the luminosity, radius is determined. It was revealed after a study of these parameters that the stars of the universe are not distributed at random but follow a definite course when arranged according to their observed luminosities and spectral types (or surface temperatures). The discovery of this stellar chart by Hertzsprung and Russell proved to be of fundamental importance for the study of stellar structure. It was found that a vast majority of stars (more than five-sixth of the whole) is included in a straight narrow band in this two dimensional Russell diagram, called the main sequence running diagonally from stars of low luminosity, small mass and small effective temperature of class M at one end to those of high luminosity, large mass, and large effective temperatures of classes B and A at the other. A portion of the remaining stars lies on another branch on the diagram with high luminosity

	Luminosity 10^{10}	Mass 10^{2}	Radius 10^{4}	Surface temperature 10	Mean density 10^{13}
Range of variation	Most luminous star S Doradus which has 300,000 times the luminosity of the sun whereas the least luminous Wolf star has only a fifty-thousandth part of the luminosity of the sun.	Heaviest are Plasket stars with mass more than hundred times the sun's mass; smallest known weight is for Kruger 60, which has a fifth of the sun's weight.	Antares has the largest diameter, 450 times the sun's diameter. Van Manne's star is the smallest known one—it is just about as large as the earth.	From 3,000 to 30,000 degrees for Plasket stars. Two O type stars of Wolf-rayet class have a surface temperature of 70,000 degrees, whereas the long period variables at their lowest temperature ranges down to 1,650 degrees.	From 10^{-7} to 10^{6} grm./cm.^{3} for white dwarf stars.

and low effective temperature. The stars of high luminosity and great size are generally called the giants and those with low luminosity and small size the dwarfs, the distinction between giants and dwarfs being well marked only for stars of low effective temperature. There is also a region near the left-hand bottom corner of the diagram which is occupied by faint stars of very high surface temperatures, known as white dwarfs. The few stars at the top of the Russell diagram which are very massive and much more brilliant than the ordinary giant stars are super giants. Sub-giants form another class of stars of G and K type which have low effective temperature and lie intermediate between the giants and the dwarfs. It is also very remarkable that there are no stars between red giants and dwarfs and between the main sequence and the white dwarf stars. A glance at Russell diagram above shows roughly the range of variation of the various physical quantities amongst different stars.

The explanation as to what makes the stars to be distributed in this particular way in the Russell diagram is the subject-matter of all investigations on the theory of stellar structure. For such an investigation we require a knowledge of the density and temperature distribution inside the stars as well as their chemical composition. A rigorous investigation on the stellar structure is possible if the opacity coefficient and the rate of liberation of energy are known in terms of density and temperature. But as these quantities are not known with definiteness recourse must be taken to some sort of model. The results obtained thereby may not represent the actual conditions in the stars but still afford some 'insight' as regards the actual conditions.

2. PROF. N. R. SEN, Calcutta.

Mathematical Theory of the Internal Constitution.

Problem.

Astronomical observations furnish three important attributes of a star, the mass, the radius, and the luminosity (the total energy radiated per second), usually denoted by the symbols, M, R and L respectively. Most of the stars radiate uniformly, that is each star gives out the same amount of energy per unit of time, and there are no reasons to believe that these stars have changed appreciably within some thousands of years. It is thus reasonable for our purpose to assume they are in a steady state in which the physical conditions are supposed not to change with time. The mathematical problem of the stellar structure consists in an enquiry about the temperature, pressure, and other physical conditions inside a very hot mass M of matter in steady state, which is rolled up into a ball of radius R, and whose surface radiates the fixed amount of energy L. The conditions well inside such a body are somewhat different from those near the surface. We shall confine ourselves to the deep interior where, as we shall see later, the conditions merge into some sort of rough uniformity for all stars.

The Mathematical Equations and their Consequences.

A mass of gas in gravitational equilibrium will be governed by the equations

$$\frac{dP}{dr} = -G\frac{M(r)}{r^2}\rho \qquad \ldots \quad \ldots \quad \ldots \quad (1)$$

$$\frac{dM(r)}{dr} = 4\pi\rho r^2 \qquad \ldots \quad \ldots \quad \ldots \quad (2)$$

Definite configurations may be obtained from these by assuming a (P, ρ) relation of which the one studied most is of the type $P = C\rho^{1+\frac{1}{n}}$. These

configurations are finite so long as $n<5$, and give spheres of varying mass concentrations. The temperature distribution within such stellar bodies suggests central temperatures of the order of 10^7K, at which most of the atoms will be stripped of their electrons. Besides, a considerable amount of radiant energy will be pent up within these bodies, which may exert a pressure comparable to the gas pressure. The total pressure P will indeed be

$$P = p_g + p_r = \frac{k}{\mu H}\rho T + \tfrac{1}{3}aT^4, \quad p_r = (1-\beta)P, \quad \ldots \quad (3)$$

if the ordinary gas law is assumed to hold good. The energy pent up within the gas mass is transmitted mainly through radiation unless the matter is degenerate. The radiative temperature gradient is given by

$$\frac{dp_r}{dr} = \frac{d}{dr}\left(\tfrac{1}{3}aT^4\right) = -\frac{x\rho}{c} \cdot \frac{L_r}{4\pi r^2} \quad \ldots \quad \ldots \quad (4)$$

where x is the opacity coefficient, and L_r the total flow of radiant energy per second across a spherical surface of radius r.

If the temperature gradient corresponding to (4) be greater than the adiabatic gradient, equation (4) is to be replaced by

$$\frac{dP}{P} = \gamma \frac{d\rho}{\rho} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

Given μ and x by physical theories, there now stand three differential equations among four quantities ρ, T, L_r, $M(r)$. A fourth equation is given by

$$\frac{dL_r}{dr} = 4\pi\rho r^2\epsilon \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

where ϵ is given for the main sequence stars at least, by Bethe's theory of energy generation.

The boundary conditions are at $r = R$, $\rho = 0$, $T = 0$, $L_r = L$, $M(r) = M$, and further at $r = 0$, $l_r = 0$, $M(r) = 0$, to avoid a singularity at the centre.

A study of the solutions shows that the whole system of solutions can be expressed in terms of two parameters, μ and M being often chosen as these parameters. This is known as Vogt-Russel Theorem.

For x we can accept Kramer's law, which is also supported by quantum mechanical calculation

$$\overline{T^{3\cdot 5}} \quad (7)$$

By all these given conditions the stellar problem is over determined, and in fact among the given parameters there is a relation of the type

$$F(x_0 L, M, R, \mu) = 0$$

which represents a mass luminosity law. A simple form of the function which can be easily deduced in case of small radiation pressure is

$$x_0 L = \text{const.} \frac{M^{5\cdot 5}}{R^{0\cdot 5}} \cdot \mu^{7\cdot 5} \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

A very simple solution of the equation (1), (2), (3), (4) was obtained by Eddington on the supposition

$$x\eta = \text{const., where } L_r/M(r) = \eta.\ L/M \quad \ldots \quad \ldots \quad (9)$$

The ratio of radiation to gas pressure becomes now constant, and is given by the quartic equation

$$(1\cdot\beta)/\beta^4 = \cdot 00309(M/\odot)^2\mu^4,$$

and the mass luminosity-law in the form

$$L = 4\pi cGM(1-\beta)$$

which in fact is identical with (7) with $\mu\beta$ in place of μ on the right. This is a fairly good approximation for the main sequence stars of small masses. Eddington calculated x_0 astronomically from (9) by substituting the known data of Capella. But this was nearly 40 times higher than the value obtained from the physical theory. Eddington's astronomical value of x_0 substituted in (9) gave a correct mass-luminosity relation for many other stars.

The H.R. Diagram.

Eddington's calculations were made with $\mu \sim 2$. But if the stars contain a large amount of hydrogen a lower value of μ will be appropriate, and the discrepancy of the x value becomes smaller, and indeed can be made to disappear by assuming a suitable hydrogen content. The H.R. diagram can then be explained by assuming the hydrogen content to be a parameter of the star. If x be the proportion of hydrogen in the stellar material, a quantum mechanical calculation of (6) gives

$$X = \frac{x_0}{t} \cdot \frac{\rho}{T^{3\cdot 5}}, \; x_0 = 3\cdot 9 \times 10^{25}(1-X^2) \quad .. \quad .. \quad (10)$$

and

$$L = 7\cdot 17 \times 10^{24} \cdot \frac{t}{x_0} \cdot \frac{M^{5\cdot 5}}{R^{0\cdot 5}} (\mu\beta)^{7\cdot 5}, \quad \mu = \frac{2}{1+3X} \quad .. \quad (11)$$

where t is a slowly changing quantity of the order of 1. From these two equations, for a given set of values of L, M, R, two values of X are obtained of which only one is appropriate. Equation (11) can be used to find the hydrogen content of a star, instead of predicting the luminosity of a star from its mass. The points of the H.R. diagram can now be exhibited as lying on two sets of curves with two parameters; one set corresponding to constant mass, and the other to constant hydrogen content. The H.R. diagram is thus explained in the light of Vogt-Russel Theorem.

The white dwarf stars form a separate group by themselves, and do not conform to the mass-luminosity law. They can be described by only one parameter and there is indeed a mass-radius relation for them.

3. Dr. R. C. Majumdar, Calcutta.

Theory of White Dwarf Stars.

The white dwarf stars, which are characterized by extremely feeble luminosities and enormously high densities, occupy the left-hand lowest corner of the Hertzsprung-Russell diagram. They are called 'white dwarf' because their surface temperatures are so high that they look much whiter than the main-series stars. A density of the order of 10^6 to 10^8 grams/cm.^{3} is not uncommon in these stars, whereas the heaviest metal known on the earth is only about 20 times dense than water.

Though this abnormally high density looked absurd in the beginning, it was, however, shown to be conceivable in the light of Bohr's atom, which being roomy objects might be reduced in size by suitable conditions. Under very high temperatures and pressures in the interior of the stars the atoms will lose their extra nuclear electrons and this reduction in size will allow the formation of superdense material. An elementary consideration of the uncertainty principle shows that the conditions of matter in these stars differ radically from those in the ordinary gaseous stars. The electrons in these stars are degenerate and obey the anti-symmetrical statistical laws and if the density is so high that the distance between the two electrons are of the order of their Compton wavelength then the relativity modification of the statistics should be taken into account. The flow of heat and light in these stars have been thoroughly studied and it is found that the degenerate gas is more transparent to radiation than the gaseous material and the transfer of energy is chiefly controlled by the conduction and not by radiation as in the case of a perfect gas star. The equation of state is independent of temperature in the first approximation and as a result the structure becomes independent of the distribution of temperature in the interior. The energy generation process also should not depend much on the temperature distribution. The extreme outer layers of a white dwarf are gaseous which being less transparent to radiation acts as a blanket and keeps the heat in. The temperature of a white dwarf is therefore not very high, it is even lower than the central temperature of ordinary stars such as sun. The investigation shows that a complete degenerate white dwarf is only possible for stars of masses which are less than $5{\cdot}7\,\mu^{-2}\odot$ (μ is the average molecular weight indicating the mean composition, and $\odot$ is the mass of the sun) and degeneracy can never be developed in a star whose mass is greater than $6{\cdot}6\mu^{-2}\odot$. The stars of masses lying between these two limits have a degenerate gas core surrounded by a perfect gaseous envelope. It is further found that for complete degenerate stars there exists a unique relation between the mass and the radius—the radius decreases as the mass increases. The average and the central densities increase however with the mass. The mass-radius relation for complete degenerate star corresponds to the mass-luminosity-radius relation for the ideal gaseous star. In the latter case the mass-luminosity relation depends very little on the radius and is therefore generally known as mass-luminosity law. But in the case of a complete degenerate star the mass-radius relation comes out to be independent of luminosity. Further, the mass-radius relation involves the mean molecular weight and hence if the mass and the radius are known one can determine the mean molecular weight and hence the composition, particularly the hydrogen contents for the white dwarf stars, which have got a very important bearing on the energy generation and evolution of these stars.

4. DR. D. S. KOTHARI, Delhi.

Stellar Energy Generation.

(i) The energy generation in the main-sequence stars is fairly well accounted by Bethe's theory. The recent experimental work in nuclear Physics relevant to this theory is discussed.

(ii) The difficulties in accounting for the energy generation in giant stars are indicated and the various theories that have been suggested are examined. No really satisfactory solution of the difficulty has been given so far.

(iii) The problem of the energy supply for the white dwarfs is discussed. An account is given of Wildhack's theory, and it is shown that the gravitational contraction is sufficient to explain the energy generation in such stars. The subjects (i) and (ii) are only discussed briefly, whereas (iii) is dealt with in detail.

VI. SUGAR TECHNOLOGY.

(Section of Chemistry.)

DR. MATA PRASAD, Bombay, presided.

MR. R. C. SRIVASTAVA, Cawnpore.

Indian Sugar Industry and its Problems.

Since the grant of protection in 1932 the Sugar Industry has developed rapidly and is now the second biggest industry in India. Bihar and the United Provinces together produce 80% of the sugar made in India, while the United Provinces alone contribute more than 50% of the total Indian produce.

The industry on its commercial side has had difficulties recently, due mainly to lack of regulation. Periods of short production have been followed by bumper crops and such large production that the limit of home consumption was exceeded and large surplus stocks had to be accumulated. But the bold policy adopted by the Governments of the United Provinces and Bihar combined with the setting up of a permanent joint Sugar Commission for the two provinces augurs well for stability and regulated development in the future.

It would, for the present condition and future prospects of the industry on its technical side, be necessary to give a résumé of what has been achieved in this direction during the last 7 or 8 years, and then to indicate some of the problems which face the industry to-day and for the satisfactory solution of which research work and extensive scientific investigation are necessary.

The present state of sugar industry in this country would have been impossible, even in spite of protection, if the valuable canes of Coimbatore were not available, and credit for this is to a great extent due to Rao Bahadur Venkatraman. What the industry needs is a cane which will be cheap to grow, which will give a high recovery and a long season, and which will be resistant to common diseases and pests, such as red-rot, borers, and pyrilla. Coimbatore has given a large number of varieties to choose from. Selection and trying out of these, combined with the development of suitable methods of cultivation, has formed the main item of work so far on the agricultural side. To get some idea of the improvement which has actually taken place, mention may be made that some of the Bombay Factories have succeeded in obtaining yields of over 100 tons of cane per acre under intensive cultivation on their own farms. In the United Provinces and Bihar the cane development work, which is being done by Government in collaboration with the Factories in areas reserved for their cane supplies, has succeeded in implementing the most important recommendation of Sir John Russel, viz., that of carrying the results of scientific investigations to the cultivator's land. The improvement in cane cultivation which has taken place, as a result of this development work, has substantially raised the yield per acre thereby lowering the cost per maund of cane. The quality of cane judged from its sugar content and the purity of its juice has also improved in these areas.

On the technical side, sugar factories have shown steady progress during the last seven years. The Sugar Technologists' Association of India makes a careful study of the manufacturing reports submitted by factories and brings out an annual publication containing detailed operating data compiled in a comparative form. A study of these shows that an all-round progress in manufacturing efficiency has been taking place from year to year. Mill extraction, boiling house extraction, and over-all

extraction, the three basic criteria for judging operating efficiency have all improved and an analysis of the increase shows that the greater portion of the improvement is due to increased efficiency rather than to better cane quality, although the latter has also improved.

Reference may be made to the improvement which has taken place in regard to the quality of sugar produced by Indian Factories. An important step for effecting improvements in this respect was the setting up of uniform standards of quality on the basis of what are known as the 'Indian Sugar Standards' issued by the Bureau of Sugar Standards maintained by the Imperial Institute of Sugar Technology. The standards permit of an accurate grading of sugar both in regard to colour and size of grain and have been in use now for over five years. Judged according to these standards, it is observed that improvement in quality has taken place in two directions. Firstly, Factories are now producing sugars of a more uniform quality and the number of grades produced is also becoming smaller. Secondly, a general rise in the quality of sugar is also taking place, so much so that several Factories are now producing sugars superior to even the best imported sugars.

Finally, on the mechanical side also the industry has given a good account of itself. Most marked improvement has taken place in three directions, namely, in better fuel economy, in reducing loss of working time during the crushing season, and in obtaining higher capacity combined with increase in efficiency. The varieties of cane grown, specially in the sub-tropical tracts of India, have all high fibre content and theoretically the quantity of bagasse produced from such canes should not only provide sufficient fuel for running the Factory but should also leave a certain amount of surplus bagasse. Till recently, however, very few Factories were able to work without burning large quantities of outside fuel, such as fire-wood and coal, the cost of these being anything from Rs.20,000 to Rs.50,000 per Factory per season. As a result of improvements made in the design and construction of boiler furnaces, and of a more economical use of steam for process, the quantity of outside fuel has considerably been reduced. Many Factories not only do not burn any outside fuel now but get such large quantities of surplus bagasse that methods have to be devised for its satisfactory disposal. In regard to a reduction in the loss of working time during the crushing season, better maintenance of the plant combined with higher skill in its operation has succeeded in bringing down the figure of lost time from 25–30% to 10–12%. This means that in a season of the same duration, the output of the Factory is increased by at least 10–15% thereby lowering the incidence of over-head charges and wages bill, thus reducing the cost of production of sugar.

It is desirable to refer to some of the problems which face the industry and to give a brief account of the work that is being done and see what further work is necessary.

The first problem, which is in fact a continuing problem, is the further improvement of the technical and mechanical efficiency of operation of Sugar Factories. The Institute assists Factories by giving technical advice and by undertaking research on problems arising in Factories. As examples of this type of work, reference may be made to the designing of special types of groovings for mill rollers, the designing of boiler furnaces, working out processes of clarification to suit the special conditions obtaining in individual Factories, and preparing schemes of sugar boiling to give better and more uniform qualities of sugar. Help is also being given in securing better chemical control over the manufacturing operations by preparing schemes best suited to each Factory and scrutinizing the periodical manufacturing reports.

A matter which has assumed considerable importance lately is that of proper storage of sugar so as to avoid deterioration. Sugar is made from cane during a season of approximately 5 months in the year whilst it has to meet the consumption requirements for a full year and has therefore to be stored for considerable periods. If the production of sugar

in any season exceeds the consumption requirements, as happened in 1939-40, large stocks have to be carried by the mills for very much longer periods. It is estimated that even under normal conditions the loss incurred by Factories as a result of deterioration of sugar amounts to about Rs.10 lakhs annually. Research work has, therefore, been undertaken to find out the conditions necessary for keeping sugar without deterioration. The investigation has been partly biochemical and partly chemical. Experiments on the biochemical side have indicated that in the first stage of deterioration moulds predominate and these are replaced by yeasts and bacteria during the later stages with increasing moisture content. The first step in improving the keeping quality of sugars is, therefore, to eliminate the possibility of introduction of moulds. As moulds are carried by dust, it is essential to improve the sanitation and cleanliness of the Factory and also the quality of water used for process. The object of the chemical investigations is to determine the critical humidity for different grades of sugars and to devise means for maintaining the humidity and temperature in the godowns within the limits of safety. This work is being done partly in the Institute and partly in the godowns of a number of sugar Factories. Finally, special attention is being given to the designing of new godowns and making alterations to existing godowns so as to make them suitable for proper storage of sugar. A scheme of technical control of sugar storage is also being evolved which will enable the factory Chemist to know when the sugar approaches the danger limit.

The disposal and proper utilization of the by-products of the sugar industry, namely, molasses, bagasse and filter press-mud, provide a very wide field for the research worker. Molasses is easily the most important of these by-products in quantity as well as in value. In the pre-protection days the return from molasses was generally sufficient to pay for the working expenses of the Factory. To-day, not only is the return negligible, but in many places Factories have to incur expenditure in getting rid of surplus molasses. In view of its great importance the problem is being attacked from different angles.

Attempts have been made to recover sugar from molasses and two or three different methods have been tried. The one which gives the greatest promise of success is that of destroying the reducing sugars with lime and precipitating sucrose by one of the alkaline earth oxides under special conditions. Seventy to eighty per cent recovery of sucrose can be effected by this method.

The preparation of edible sugar syrup from molasses has also been tried with satisfactory results. The process consists in precipitating the sugars in molasses with quicklime under special conditions followed by suitable subsequent treatment.

Extensive experiments on the preparation of cattle feed from molasses and bagasse have been undertaken under a scheme financed by the Imperial Council of Agricultural Research. A feed containing mixture of two parts of molasses and one of bagasse has been produced and has satisfactorily undergone feeding trials in a number of animal nutrition centres throughout India. The product, which has been given the name of BAGO-MOLASSES, has now been standardized and the necessary machinery for producing it commercially is at present being designed.

A process has also been developed for using molasses for road making. An insoluble resinified road composition has been made from molasses, the basis for the process being the combining of the aldehydes and ketones in molasses with the phenolic bodies in coal-tar and asphalt in the presence of an acid or alkali catalyst to form a resinified compound. A length of road treated with this composition has been in use now for 4 years and is still in a good condition. The P.W.D. are now treating with this composition a short length of an important public road near Cawnpore.

The manufacture of acetone and butyl alcohol from molasses has given satisfactory results in the laboratory and the process is now to be

tried on a semi-commercial scale. A simplified process has also been developed for the dehydration of alcohol for the manufacture of power alcohol, the dehydrating material used being fused potassium acetate and caustic potash.

Several workers have tried the use of molasses as manure and it has been found that apart from the question of its suitability for this purpose, the cost of transport and application renders this method of utilization of molasses uneconomical. The direct application of molasses to the soil also leads to retardation of plant growth due to the accumulation of acids resulting from the fermentation of molasses. So long as the alkalinity of the soil is adequate to deal with the acidity, no deleterious effects are discernible. But with heavier or repeated applications, the depressing effect becomes evident. The concentrated manures prepared by the biological method developed in the Institute have no such drawbacks. They consist of yeast, calcium salts of organic acids and nitrogenous decomposition products, all of which are valuable plant foods. The Imperial Council of Agricultural Research has recently sanctioned a scheme for large scale production of concentrated molasses manure in collaboration with Sugar Factories.

Turning now to bagasse, which is another important by-product, the problem of its disposal has not yet assumed the same importance and urgency as that of molasses. The manufacture of cattle-feed from bagasse and molasses, to which reference has already been made, forms one method of dealing with surplus bagasse. Another method of utilizing surplus bagasse, which is at present under trial, is that of composting it along with cane trash and filter press-cake in order to produce a valuable manure. Various methods of composting are being tried and experiments are simultaneously being conducted in a few Sugar Factories which have their own Cane farms.

Filter press-mud, the last by-product to be considered, has been successfully tried as a raw material for the manufacture of activated carbon. The product obtained compares favourably in quality with some of the best imported carbons and it is now being manufactured on a semi-commercial scale and supplied to Oil Mills and Sugar Factories.

The Indian sugar industry consumes annually over 7,000 tons of imported sulphur and of this nearly 3,500 tons goes to waste in a combined form in press-mud. Experiments are therefore in progress for devising a method for recovering at least a part of this waste sulphur and also for the manufacture of sulphur compounds, such as sodium thiosulphate.

More recently a dye-stuff of the sulphur group has been obtained from press-mud after removing the mineral matter from it by a pre-treatment. On suitable modification the dye-stuff gives a shade of khaki, which matches with the standard khaki.

The problems connected with the disposal of by-products have been dealt with so far. Before concluding, reference may be made to a problem of a much more fundamental nature. The sugar industry in India is confined to the manufacture of white sugar which is consumed mainly by the well-to-do sections of the population. The bulk of the population, however, cannot afford to eat sugar and has to be content with cheap and inferior products like *gur* or *jaggery*. These are produced by cane growers by crude and inefficient methods. Several attempts have been made in the past for manufacturing *gur* on a factory scale but they have invariably failed as the product which was obtained did not have the characteristic colour, flavour and consistency of *gur*, even though it was chemically much purer than *gur*. The consumption of *gur* in India varies between 2-3 million tons annually as compared with a little over a million tons of white sugar. It is obvious, therefore, that if a satisfactory process can be developed for manufacturing in Sugar Factories high grade *gur* or brown sugar possessing the characteristic features of *gur* the entire sugar industry of this country will be revolutionized. Work on this problem

is at present in progress in the Institute Laboratories and in the Experimental Factory.

This finishes a survey of the problems of the Indian sugar industry, but before closing an appeal, or rather, two appeals may be made. The sugar industry is now an important industry and some idea of the large number and varied nature of the problems with which it is faced has been given. In the interest of the industry and in the larger national interest, it is necessary that research work directed towards its improvement should be done on as wide a scale as possible. For this purpose an invitation is extended for an exchange of ideas and closer collaboration with workers in the Universities and other Research Institutions. The Institute has already in operation a scheme for co-ordinated research work in collaboration with Technologists working in Sugar Factories. A similar scheme of co-operation with fellow workers in Universities and other Institutions is equally desirable and would be most welcome.

The second appeal is to the Science Congress. Thanks are due to the authorities of the Congress for affording the sugar workers this opportunity of discussing sugar research, but the importance of the industry demands that the present symposium should become a regular annual feature in the future and that at least one whole day should be allotted to it. It is hoped it would be possible to arrange for this.

The following are the questions and answers that followed the paper:—

(*a*) which factories had succeeded in obtaining crops of 100 tons and over;

(*b*) what was meant by the term 'efficiency' of sugar factories and how it was ascertained that an improvement in efficiency had taken place;

(*c*) whether sufficient surplus bagasse would be available for making cattle-feed by mixing with molasses; and

(*d*) what was the present source of supply of sulphur for sugar factories in India.

Mr. Srivastava in reply stated that sugar factories in the Bombay Presidency grew their own cane and several of them entered the competition for producing heavy cane crops. He mentioned the names of the factories at Ra algaon and Kalamb which had obtained yields of more than 100 tons of cane per acre on their own farms. Some private growers also had obtained similar yields.

In regard to the term 'efficiency', Mr. Srivastava explained that this referred to the mill extraction (i.e., Pol. extracted in mixed juice per cent Pol. in cane) the boiling house extraction (i.e., Pol. in finished sugar per cent Pol. in mixed juice) and the over-all extraction which is the product of the mill extraction and the boiling house extraction.

As regards the availability of a sufficient quantity of bagasse for making cattle-feed, Mr. Srivastava explained that all the bagasse available was not used for this purpose. The bagasse as it came out from mills was automatically screened in the bagasse carrier and only the fine portion (which consisted mainly of the soft pith fibre) was used for making the cattle-feed. There should be no difficulty in obtaining the required quantity of bagasse as the fibre content of Indian canes was generally higher than that required for producing steam in the boilers. In fact, several factories with efficient boiler plants got such large quantities of surplus bagasse that its disposal was becoming a problem in itself.

Finally, in regard to the source of supply of sulphur, Mr. Srivastava pointed out that although the usual quality of double refined Italian sulphur was no longer available, there was no difficulty in obtaining supplies from the United States, Java and Japan. The American sulphur was of the same high quality as Italian sulphur but its price was very much higher. The sulphur obtained from Java and Japan was cheaper but of an inferior quality and instead of being in the form of rolls it was usually supplied in the form of lumps mixed with a large proportion of

sulphur dust. The dust gave rise to difficulties in burning and to overcome these difficulties improvements had been introduced in the sulphur burning plant.

2. DR. K. A. N. RAO, Cawnpore.

Sugar Factory By-products.

Of the sugar factory by-products, mention may be made of cane trash (93,000 tons per annum in sugar factories), bagasse (only in a few factories), filter press-cake (2,32,500 tons per annum), molasses (about 500,000 tons per annum), and furnace ash and clinker.

Molasses.—The most important of these is molasses. Investigations have been carried out to utilize molasses in different ways.

A. *Recovery of sucrose.*—(i) By treating molasses with a mixture of ethyl alcohol and glacial acetic acid under suitable conditions, 50–75% of the sucrose in molasses has been recovered.

(ii) Sucrose has also been recovered by destroying the reducing sugars in molasses either by boiling with lime or by treatment with non-inverting yeasts and then precipitating sucrose by one of the alkaline earth oxides. Conditions of precipitation vary for the different oxides, as also the recovery of sucrose which ranges from 75–85%. The laboratory results have been confirmed in the factory in some of these cases.

B. *Edible syrups.*—The sugars in molasses (37% sucrose, 15% reducing sugars) can be precipitated by specially prepared quicklime under defined conditions and by decomposing these lime-sugar compounds and suitably treating the resulting sugar solutions, a table syrup possessing good taste, colour and keeping quality, and comparing favourably with the well-known products on the market is obtained. A recovery of 80% of the sugars in molasses can be effected by this method; 100 maunds of molasses can be converted either into 60 maunds of syrup of 75° Brix or into 50 maunds of *gur*.

C. *Cattle-feed.*—A nutritive cattle-feed named 'Bago-molasses' has been prepared from bagasse screenings and molasses, with or without the addition of oil-cake. It has been tested in the Nutrition Centres by being fed to cattle during prolonged periods and has been found to be satisfactory.

Filter press-cake.—By extraction with the usual solvents, cane wax has been recovered from dried filter press-cake in yields of 10–12%, and after bleaching by the usual methods, a wax melting at 58°C. has been obtained. Large scale experiments are on hand for its extraction and its properties are under examination with a view to its utilization.

Cane trash, Filter press-cake and Bagasse.—Experiments carried out with cane trash (0·24% N, 28·0% C), filter press-cake (1–1·5% N, 4-5% P_2O_5, 10% CaO, 2% K_2O, 40% C on dry basis) and bagasse (0·14% N, 40% C) have shown that a compost of good quality can be prepared starting from a suitable mixture of these materials, in a period of about 6-7 months. Cowdung slurry is used as an activator and in order to minimize expense, the heaps are not subjected to any turning. The compost contains 1·6% N, 3·3% P_2O_5 and 0·86% K_2O.

Furnace ash and clinker.—Detailed analyses of these products from different factories are being carried out with a view to determine the suitability of these products for the manufacture of glass.

3. DR. A. N. RAO, Cawnpore.

Utilization of Sugar Factory Press-mud.

11,000,000 tons of sugar-cane are on an average annually crushed in the Indian sugar factories. Eighty-five per cent of this is worked

by the sulphitation and the remaining 15% by the carbonatation process. Sugar factory filter press-mud, a waste product whose disposal has still been a problem facing the manufacturers is obtained in both the processes, its yield in the sulphitation plants when wet being about 2·2% on cane while it is much higher (7·38%) in the carbonatation plants. Carbonatation press-mud containing a much larger amount of mineral matter particularly in the form of calcium carbonate can be used for certain purposes—for recovering lime by burning suitably in lime kilns, in the cement industry in place of lime-stone, or as a filter aid for use in alkaline media after burning off the organic matter under controlled conditions of combustion; some of these aspects are being still looked into. Sulphitation press-mud containing on the other hand over 60–65% organic matter when dry has so far been attempted to be used in most unprofitable ways and there are cases reported where factories are even prepared to pay and get rid of the filter press-mud from their premises. Several uses to which it has so far been tried are—(i) as a fuel, (ii) as a manure used directly or after composting it with other organic waste materials so as to diminish the mineral matter in the final product and to increase the nitrogen content, (iii) as a source for cane wax.

In spite of the large amount of combustible organic matter present, the first method has not been useful for industrial purposes mainly due to the presence in press-mud of large amounts of clinkering inorganic materials. The possibility of employing the other methods have been discussed in another paper already. The writer and his collaborators have however developed the following possible profitable avenues for the utilization of sugar factory press-mud and brief descriptions are given below.

(i) *For the manufacture of Activated Carbons.*

The consumption of activated carbons in India has so far been only in the neighbourhood of 2,000 tons (estimated) excluding the quantity that has been used in the indigenous *gur* industry, the only possible industries consuming it having been oil refining, fine chemicals, pharmaceuticals, and aerated water syrup. Apart from the rapid development of some of these industries in India contributing to an increasing demand for activated decolorizing carbons, a large potential source for its consumption is the sugar industry itself. With attempts at improving the quality of white sugars, a carbon treatment at a suitable stage in the existing plants or after the sugar has been manufactured become essential and anywhere about 12,500–13,000 tons of good decolorizing carbons would be necessary to treat the whole of India's total output of sugar by the sulphitation process only. If carbon treatment in white sugar manufacture has not so far been widely introduced in India, it must be entirely attributed to the unduly high prices of the imported carbons on the market making their use uneconomic. Sugar factory press-mud containing the necessary activating chemicals already *in situ* offers a valuable source for the production of high quality decolorizing carbons and the 8[illegible],000–90,000 tons of dry press-mud from all the sulphitation factories can yield 14,000 to 15,000 tons of carbon to satisfy the entire requirements of all industries.

The process developed consists in igniting the press-mud out of contact of air at suitable temperature of the order of 800–900°C. and the ignited mass being afterwards treated with suitable mineral acids or acidic gases to leach out all the mineral matter leaving the surface and the pores in the carbon open. The carbon obtained is well washed, dried, sized and is ready for use. It has been found that irrespective of the source of press-mud, the carbons are always highly active and possess very good decolorizing powers towards vegetable oils, caramel and impure sugar solutions. In their decolorizing properties, they compare favourably with even some of the high priced vegetable carbons in the market.

(ii) *For recovering Sulphur or manufacturing useful sulphur compounds.*

India imports annually about 29,000–30,000 tons of sulphur and several millions of rupees worth of sulphur compounds like sodium sulphide, sodium thiosulphate, hydrosulphite, etc. Over a quarter of the sulphur imported is consumed in the Indian sugar industry, and most of it by the sulphitation factories. Although nearly 40–45% of the sulphur consumed either goes to waste or becomes irrecoverable, the rest of it (55–60%) passes into the sugar factory press-mud and is present in it in a combined condition either as, sulphate or sulphite. Attempts have been made to recover the sulphur from the press-mud at an intermediate stage in carbon manufacture—from the ignited mass containing the sulphur in the form of sulphides and before these are decomposed by the action of acids to remove the mineral matter. Although the cost of recovered sulphur may be high when compared to the natural imported product during peace time, during times like the present when imported sulphur is scarce and is not available, the price of recovered sulphur would be competitive and the method appears feasible. During peace time however, instead of recovering the sulphur as such, it is preferable to convert all the sulphur present in a combined condition in press-mud into useful sulphur compounds like sodium sulphide, sodium thiosulphate, etc., from the sulphides present in the ignited mass. When these processes are carried out in conjunction with carbon manufacture and the products are obtained from the ignited press-mud before subjecting it to the final acid treatment, the overhead charges get distributed and both products become cheaper. There should be no difficulty in putting the products in the market at competitive prices.

(iii) *For the production of a Dye-stuff.*

Another important use to which sugar factory press-mud has recently been put is the manufacture of dye-stuffs. In the process developed at Cawnpore, the press-mud is first treated with suitable mineral acids or acidic vapours and the organic matter carefully separated from the acid solution and washed free from acid. The mass obtained is treated with the necessary chemicals to obtain a dye of the sulphur class. As is common with the dyes of this group, the dye produced from press-mud dyes all vegetable fibres and is fast to an equal extent. The shades that can be obtained though normally chocolate can be varied to yield anything from chocolate to khaki, when necessary by having recourse to combination dyeing.

A discussion on this paper was as follows:—

Prof. P. S. Varma, Benares, wanted to know from Dr. A. N. Rao the comparative decolorizing powers of the press-mud and other imported carbons if they have been determined.

Dr. K. Venkataraman, Bombay, said that from what is understood, press-mud contains mostly only organic substances with long open chains and the formation of sulphur dyes using compounds of this nature is not common. The manufacture of a dye-stuff from press-mud is therefore of more than passing interest and the subject should be investigated completely since even apart from the industrial value of the dye-stuff, its nature and the conditions under which it is produced would itself be interesting subjects for detailed investigation.

Mr. N. L. Vidyarthi, Waltair, enquired that whenever decolorizing carbons are used in sugar and other industries, if their use is to be economic, it should always be possible to revivify the carbons after use. I would like to know how far it has been possible to reactivate the press-mud carbons.

Dr. M. N. Goswami, Calcutta, said that if it is not a secret and if the information could be supplied, I would like to know how the sulphur dye-stuff can be produced from press-mud.

In reply to the above Dr. A. N. Rao said:

The data of the decolorizing powers of press-mud and a few of the best activated carbons in the market are available not only with reference to caramel and molasses solutions but also vegetable oils. The limited time at my disposal during the presentation of the paper did not permit my projecting the data and Prof. P. S. Varma can get them from me any time he wants.

In connection with Mr. Vidyarthi's question, I wish to point out that the possibility of reactivation comes up only in industries where the quantities of carbon consumed are large since the cost of the revivification plant is invariably high. So far in India there have not been many industrial units consuming large quantities of carbons. Besides, press-mud carbons are cheap and it is difficult to say if much advantage could be secured by reactivation of these carbons in normal times. But I must however point out that these carbons can be reactivated and used thrice or sometimes even four times in the process.

In connection with Dr. K. Venkataraman's remarks, it must be pointed out that the chemistry of our dye has not yet been investigated, and so far only its technology has been developed. I understand that even in the cases of some of the widely used sulphur dyes in the market, although their fundamental chemical nature is known, in most cases their technology has been developed more than their chemistry. In fact, the chemistry of sulphur dyes though it has attracted the wide attention of organic chemists, has still been baffling them, particularly in cases like the present where the dye has been produced from waste materials. As regards its formation from open chain compounds present in press-mud, I do not see why ring formation may not have taken place during its treatment with acids or acidic gases or during the formation of the dye-stuff. So far as we can say at the moment however, a useful dye-stuff can always be obtained from press-mud without any difficulty. From the reports of one of my textile friends, the dye although of the sulphur class does not answer the tests for most of the known substances. The detailed investigation of its chemistry and also whether it still contains the open chain may be carried out by any interested organic chemist.

The details of the method for obtaining these dye-stuffs are soon being published and anybody interested may obtain the information.

Finally, Dr. J. C. Ghosh enquired whether the press-mud carbons could be used for gas absorption and in other industries like oil refining. It was explained to him that these carbons are eminently suited for decolorizing vegetable oils but since they are fine and are probably not of very open structure, their use for gas absorption had not yet been investigated.

4. Dr. H. D. Sen; Cawnpore.

Some of the present day-problems of the Sugar Industry.

One of the main items of investigation, which required immediate solution at the Imperial Institute of Sugar Technology, was to find out all possible avenues for the utilization of molasses and other waste products of the sugar industry. The Biochemical Section of the Institute has not been lacking in attaining the object in view and is in possession of a good deal of information, not hitherto available, which may be of service in initiating new industries in this country.

A short résumé of the researches carried out in the Biochemical Laboratories on the above subjects and also on other biochemical aspects, during the last decade would not be out of place. As early as 1924 investigations were undertaken into the nature of unfermentable sugars present in the spent wash. The reducing bodies were found to consist

of gums of galactanxylan type and hence incapable of fermentation. In 1935 complete analysis of typical samples of sulphitation, carbonation and refinery molasses from Indian sugar factories gave an insight into the exact nature of the impurities present and led to the formulation of a law by which the true purity of outgoing molasses may be easily determined from the apparent gravity, purity and ash.

The problem of the recovery of sugar from molasses by destroying the reducing sugars with a strain of invertase free yeast *Saccharomyces Mali-Duclauxi*, isolated from cider apple, was tackled in the same year. The particular yeast strain had the property of diminishing the reducing sugar content by 17·6 units and elevating the purity of molasses by 18·1 units. After fermentation the molasses solution was sparkling in colour and devoid of most of the gummy and albuminous matter. The next operation consisted in precipitating sugar from its salts by the calcium saccharate process, giving a light coloured syrup of as high a purity as 90% and the sugar obtained by crystallization, having a purity range between 92–94%. The process is simple requiring a few fermenting vats and needs addition of a small refrigerating unit to the sugar factory.

In the year 1936 a process was perfected for the treatment of sugar factory effluents based on the observation that a preliminary operation of fermentation of all the saccharine matter in the waste water was indispensable prior to any chemical treatment by blowing air vigorously in presence of a mixed bacteria, consisting of *B. Coli*, yeast, acetic, butyric, and lactic acid organisms, obtained by the self-fermentation of molasses as a black sludge from the condenser water tanks at the end of the cane season as starter. The next operation consisted in the flocculation of the colloids by adding milk of lime to pH 7·0 and finally oxidising any residual organic matter with potassium permanganate or E.C. The treatment brought down the oxygen absorbed value from as high as 64 to 4–6, satisfying the Public Health requirements. The process is being adopted in sugar factories. The standard for the outgoing effluent after treatment has been fixed at a conference in consultation of the Provincial Hygiene Institute, U.P. and Department of Public Health and has been recently supported by a G.O. from the U.P. Government, restricting the letting out of foul water without treatment in rivers and canals, and ensuring frequent testing of the treated effluent water, according to the standards laid down.

During 1937–40 a series of investigations was undertaken as regards the comparative efficiencies of direct application of molasses in the soil or its application after conversion into manure by the biological method. The data collected indicate that retardation in plant growth takes place due to the accumulation of acids as a result of fermentation, no deleterious effect being observed so long as the alkalinity of the soil can cope with the acidity produced, but depressant effect is invariably evidenced with increased application. The biological process consists in the fermentation of molasses with heavy aeration at the neutral point by intermittent addition of milk of lime or soda. The process was developed on the observation that fermentation under acid condition led to loss of nitrogen while under neutral condition led to its conservation. The N content of molasses was 0·25% whereas the N content of the manures prepared from molasses was as high as 1·5–2·1%. The manures consist of yeast, calcium salts of organic acids and nitrogenous decomposition products, all being good foods for the soil flora. The nitrogenous bodies are said to contain auxins, the important plant hormones. The cropping tests in randomized blocks have given high crop yields with higher sugar content with much smaller applications of the concentrated manures per acre, 37·5–7·5 mds. as compared with direct application of molasses to the tune of 600 mds. of molasses with much less outturn. The response of the manures in alkaline soils has also been good, their application leading to good growth in patches, where no crops will grow, indicating improvement in soil fertility.

Experiments on cane dryage and preservation, carried out during 1936–38, with thirteen different cane varieties, indicated that the resistance to dryage varied with different species, some being more resistant than the other. The deterioration was mainly bacterial, the bacterial count in the deteriorated cane increasing from 250 to 3,000 per c.c. during one month's storage with remarkable predominance of *B. Aceti,* although there was appearance of *Penicillium Glaucum* on the cut ends. Keeping in the shade, sprinkling with water, or treatment with 1% boric acid had only partial effect of preventing deterioration. The process of windrowing, i.e., storing cane covered with earth, prevented deterioration to a remarkable degree, the sugar content and juice quality remaining unaffected for one and half months. Windrowing as a means for preserving cane has not been adapted anywhere, it being adapted so far for protecting cane temporarily from frost. It has got a great future and needs further to be investigated.

An intensive study on the bacterial aspect of the keeping quality of Indian sugars has also been carried out. The researches have led to the isolation of a large number of moulds, mucors, yeasts and bacteria. The results indicate that the main factors responsible for the deterioration of Indian sugars are (1) layer of molasses film surrounding the sugar crystal, and (2) moisture. The deterioration starts with the advent of the rainy season when the molasses film attracts moisture and bacterial action sets in. During the early stages there is the appearance of mould, which reduce portion of the sugar into invert sugar. As the dilution increases, moulds disappear and the yeasts and bacteria predominate. The polarization diminishes further as a result of the action of both types of organisms but in case there is a predominance of non-inverting strains of yeast, as *Saccharomyces Octosporous,* there is observed an elevation in polarization due to the destruction of reducing sugars. The bacteria most frequently met with in contaminated sugars are of the potato group and are gum forming, *B. Vulgatus, B. Mes. Fucus,* etc. Investigations on the effect of inoculating sterile sugars with the isolated organisms show that the maximum deterioration is effected by some strains of *Aspergillus— A. Terrus, A. flavus,* etc. The next in order is *Sacch. Cerevicae* and *Mucors,* like *Cunnighamella Epiculatus,* which is a soil organism. The main attempt, therefore, should be to remove all possibilities of occurrence of moulds, which act even at a lower moisture content. It was observed that the safety factor, which depends on non-sugars and moisture, does not hold good and there is deterioration even when it is below 0·33, the recommended limit. It is thus indicated that although sugar should keep well if care is taken to keep the humid conditions of the godowns above the critical point (humidity 75%) one cannot be certain that the sugar will not deteriorate. There is possibility of the spores of moulds being carried through dust. Hence the immediate solution is to improve the sanitary conditions of the factory and attend to the cleanliness of the manufacturing plant and the factory well water. *B. Megatherium* which is a puss forming bacteria, was definitely isolated showing that the factory was using unclean water. The aim should be at the production of 'bacteria-free' sugar.

A study has also been made of the possibility of resinification of molasses with coal-tar and asphalt in presence of an alkali or acid catalyst for the preparation of a composition suitable for road surfacing, making use of the property of the aldehydes and ketones in molasses to combine with the phenolic bodies in coal-tar and asphalt. The condition preliminary to the resinification is to dehydrate molasses completely. The process has drawn the attention of scientists from different parts of the world and the success so far attained promises to have a great future. Compositions of varying consistencies both of the acid and alkali resinification have been tested in the Ordnance Laboratories, Cawnpore, according to the British Standard Specifications and small scale road trials have indicated the sustenance of the road in fairly heavy traffic. Large scale

road trials in one of the busiest thoroughfares of Cawnpore is in progress. The importance of the invention cannot be ignored, for if proved successful, it will consume the whole of the output of molasses in India leading to the construction of approximately 7,000 miles of 21 broad road every year.

Coming to the most important problem of utilizing molasses for the manufacture of solvents an epitome of the activities in this direction may be given. The question of the manufacture of absolute alcohol was taken up as early as 1933, when different processes of dehydration were examined—lime pressure method, salt, azeotropic, glycerine, gypsum and alumina processes. The discovery that fused potassium acetate gave an ideal dehydrating agent was established without any knowledge of the composition of the Hiag salt in the Biochemical Laboratories, and it may be claimed that this was the first observation. It transpired later on that Hiag was using a mixture of sodium and potassium acetates. Difficulty was later on experienced in reviving the spent salt by fusion at a high temperature, which led to the partial decomposition of the acetates giving potassium carbonate, acetone, carbon dioxide and acetic acid and led to crystallization in the Hiag column. A solution was found in using a mixture of potassium acetate and caustic potash, which prevented decomposition and lowered the fusion point of the salt, being easily soluble in alcohol. The salt mixture was patented in 1935. While the azeotropic process of Mello should be the best method for the dehydration of alcohol it is handicapped by the limited supply of the entraining liquid, benzene, and its possible loss in tropical countries during the manufacturing operations. The improved salt process is safer to work since the dehydrating salt can be obtained in any amount from acetic acid, the manufacture of which by the fermentation process has been established by the recent researches carried out in the Biochemical Laboratories.

An improved still was designed and patented, which ensures intensive rectification with dehydration and obviated 'pocket formation', as frequently observed in the Hiag still, in which every particle of alcoholic vapour is made to pass through the dehydrating mixture. The later developments in the designing of a large sized still, based on the laboratory apparatus, was made in collaboration of Mr. D. H. Dickson, the Chief Chemist and Manager of Rosa Distillery, U.P.

In examining the possibility of the manufacture of glacial acetic acid from molasses a fair amount of success has been obtained. While there were apprehensions whether acetic acid of fermentation process can compete with products from wood distillation or synthetic methods, work done has established that fermentation can be effected in a week with the help of *B. Aceti*, Hansen, pure cultures of which can easily be obtained from cane juice. The organism thus isolated can be acclimatized to molasses fermentation with ease. The average yield obtained from semi-large scale experiments comes to 331 lb. per ton of molasses and the manufacturing cost 3·1 annas per lb. giving a return of the cost of molasses at 4 annas per md. In the above experiments glacial acetic acid was obtained via potassium or sodium acetate but recent researches have shown that concentration of dilute acetic acid can be effected directly by azeotropic distillation with such entraining liquids as ethyl acetate. Distillation in vacuo for the purpose of concentration is giving promising results. A sample of acetic acid made by the fermentation process has been reported to be suitable for the effective production of rayon silk by the cellulose acetate process.

During 1935–40 the investigation on the isolation of a suitable organism for the manufacture of butyl alcohol and acetone from molasses was undertaken. A strain of *Clostridium acetobutylicum*, isolated from barley, has been acclimatized to molasses fermentation and gives an average yield of 10% acetone and 20% butyl alcohol on the total sugars in molasses. The practical yields, carried out in the semi-large scale, but in disconnected units, are lower than this but it is computed that the manufacturing cost of mixed solvents comes to round about Rs.2 per

gallon, while the pre-war rates amount to Rs.4 per gallon approximately. There are indications that the yield will increase, working with a complete unit, the construction of which is in contemplation. Expectations of higher yields of acetone and butyl alcohol have materialized in the recent observation that the organism has a great avidity for pentose sugars and admixture of extracts of bran has given satisfactory results. The examination and isolation of Clostridium acetoethylioum, producing only acetone and ethyl alcohol are also in hand.

The conditions of high yeast yield from molasses have also been determined. There is indication that fermentation at the neutral point with vigorous aeration tends to increase the yield. A few strains of yeast, which are high yielders have been isolated and preserved. Yeast cakes, having good raising properties, have been prepared for bakeries, and for use as cattle fodder. Concentrated invertase solution, suitable for the manufacture of golden syrup, has been prepared from yeast (D.C.L.) and successfully tried at the Sugar Experimental Station, Bilari.

The conditions for the conversion of starch into glucose, both by the chemical and biochemical processes, are being investigated and pure solid anhydrous glucose has been prepared. It is contemplated to add ergosterol or calciferol (irradiated ergosterol), prepared from yeast, in order to manufacture glucose D. In the biochemical process Aspergillus Orayzae has been employed for the preliminary saccharification of starch. Should the biochemical process prove successful it will effect considerable economy in the manufacturing process. The problem was taken up since glucose, solid and liquid, is essential for the confectionery industry.

In the present year the sugar industry is passing through a crisis, there being surplus stock of unsold sugar in every factory. This has led to the limitation in the quota of sugar-cane to be crushed, leaving a large amount of sugar-cane in the fields to be wasted. The storage of the standing crop till the next cane season is a serious problem and is not easy to be solved. With a heavy sugar production with no export facilities, such crisis is apt to recur again, for the total production of sugar from 150 sugar factories in India cannot be used up possibly for internal consumption only. During the war-time when the prices of all commodities have gone high, it is but natural to anticipate that the sugar consumption per capita will go down. Therefore, more uses for sugar must be found. The production of high grade sugar by activated carbon treatment and manufacture of confectionery are some of the methods of its solution since in that way more sugar may be brought in a presentable form to the consumers. It is expedient to divert a portion of cane for the manufacture of alcohol, vinegar, acetic acid, even acetone and butyl alcohol, directly from cane juice. In factories, having attached distilleries under its control, as in Shahjahanpur Sugar Factory, Rosa, it is usual to manufacture alcohol directly from cane juice or to use high test molasses (60 purity) for its direct production with less yield of sugar. A suggestion is that in the absence of distilleries the surplus cane juice may be utilized for the production of yeast, which will be of great use for feeding horses during war-time and conversion of the fermented wash to acetic acid by *B. Aceti* and manufacture of acetone from calcium acetate. The next solution will be to convert the surplus juice into industrial alcohol and store it in store vats. It is a good sign that the Governments of U.P. and Bihar have recently laid down the legislation for the compulsory admixture of absolute alcohol with petrol for use as motor spirit. This will consume a portion of molasses and cannot be feasible unless legislation is made on an All-India basis and compulsory admixture is promulgated all over India. Another method of utilization of molasses for the production of industrial alcohol is to mix it with kerosene for use for lighting and heating purposes. Investigation on this point was carried out as early as 1935 which led to the production of 'alcocene oils' by admixture of various grades of kerosene with absolute alcohol with or without the addition of a homogenizer.

If the sugar industry is to stay it is essential that there should be more and more distilleries, producing various solvents, alcohol, acetone, butyl alcohol, acetic acid, since they form the basis for manufacturing varied chemicals, pharmaceuticals, cosmetics, food products, plastics and rayon.

The question and answer that followed are:

Dr. J. C. Ghosh, Bangalore, asked as to how far research on the production of butyl alcohol and acetone had proceeded at the Institute and what would be the probable cost of their manufacture.

Dr. B. C. Guha, Calcutta, gave some information on the subject. He said that Dr. Sen and himself had isolated a strain of *Clostridium acetobutylicum* as also other strains of *Clostridium acetoethylicum* and *Acetobacter Xylinium* which give varying yields of acetone, butyl alcohol, etc. In the case of *Clostridium acetobutylicum* the yield obtained had been on the average, 10% acetone and 20% butyl alcohol on total sugars in molasses.

Dr. H. D. Sen, Cawnpore, in reply to the above, said that the practical yields, carried out in semi-large scale but in disconnected units were lower than that but it was computed that the manufacturing cost of mixed solvents came to round about Rs.3 per gallon, while the pre-war rates amounted to Rs.4 per gallon, giving a return of 4 annas per md. of molasses to the sugar factories. There was every likelihood of a further economy being affected while working with a complete unit.

Dr. J. N. Mukherjee, Calcutta, wanted to know from Dr. Sen when acetone and butyl alcohol could be got in quantities in India. He was not certain if there was even a single plant working at present. There was erected an acetone plant long time ago at Nasik. Why was that plant closed down? Had it something to do with the organism?

Mr. J. P. Shukla, Cawnpore, said that they had found the optimum conditions for the preservation of the particular strain of *Clostridium* isolated in their laboratory. It all depended on the culture of the most resisting types obtained by repeated shocking of the spores. The spores obtained after five or six transfers and three shockings give the best yield. Colstridium formed a group of organisms, which have heat resisting spores and if the mashes were not properly sterilized, the spores of other *Colstridia* survived. They developed and suppressed the growth of pure strain of *Clostridium acetobutylicum* and as a result lower yields were obtained. The closing down of the Nasik factory might have been due to likely contamination when handling large amount of mashes.

Mr. N. L. Vidyarthy, Patna, wished to know from Dr. Sen whether the road surfacing material from molasses was insoluble and how its manufacturing cost compared with road tar.

Dr. H. D. Sen said that the resinified compound was fairly insoluble, the resinification being carried to a point when a ball immersed in water remained insoluble for 15 minutes. The manufacturing cost came to Rs.50 per ton whereas the road tar cost Rs.150 per ton.

VII. RECENT ADVANCES IN THE CHEMISTRY OF COUMARINS AND CHROMONES.

DR. MATA PRASAD, Bombay, presided.

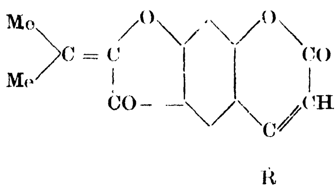
DR. J. N. RAY, New Delhi.

Furocoumarins.

The first successful effort for the preparation of furocoumarins was that of Limaye, in which by the Fries migration 7-acyloxy coumarins

he prepared 8-acyl-7-oxy coumarins which were transformed into furocoumarins after condensation with chloroacetic acid. The isomeric 6-acyl derivatives are usually formed in very small yield. Ray and collaborators prepared phenacyl derivatives or acetonyl derivatives of 7-hydroxy coumarins and cyclized these to linear furocoumarins, with traces of sodium ethoxide.

Ray and collaborators have found that ω-chlororesacetophenone condensed with acetoacetic ester and other β-ketonic esters to give 6-chloroaceto 7-hydroxy coumarins (with β substituents). These easily cyclize with sodium acetate to related coumaranones. These condense with acetone in dimethyl aniline solution in presence of a few drops of piperidine to give monomolecular condensation products of the type I.



The substance I, R = CH_3, can be reduced at the exo-cyclic double bond catalytically giving a homologue of oreoselone. Use of oxaloacetic ester has given I, R = COOEt, whence oreoselone is being prepared.

2. Dr. R. C. Shah, Bombay.

Synthesis of Coumarins.

The following researches of the author and his collaborators were described :—

(1) The influence of the acyl groups, and carbethoxy group in the resorcinol and phloroglucinol nuclei on the Pechmann condensation were studied, and hydroxy coumarin-carboxylic acids and hydroxy-acetyl coumarins synthesized.
(2) The use of aluminium chloride, a new reagent for the Pechmann condensation, has yielded remarkable results, the most important being the formation of the hitherto unknown 5-hydroxy coumarins, which are now thus made readily available.
(3) 2-Aldehydo-resorcinol-ketones and esters, obtained through the modified Gattermann reaction of Shah and Laiwalla, have been utilized for the synthesis of interesting 5-hydroxy coumarin derivatives and furocoumarins.
(4) The hitherto unknown 4 : 5-dimethyl-7-hydroxy coumarin has been synthesized from *p*-orsellinic acid.
(5) The Kostanecki acylation of orcacetophenone gives 4-acyl-methyl coumarins, instead of the expected chromones, probably due to the steric effect of the 5-methyl group. The formation of 4-acyl-methyl coumarins has been observed for the first time. A new and convenient technique has been developed for the stepwise elimination of *o*-acyl and *c*-acyl groups from *o*-acyl-*c*-acyl coumarins and chromones.

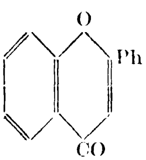
(6) Pechmann condensation of ethyl α-resorcylate with acetoacetic ester gives a 5-hydroxy coumarin derivative, while α-resorcylic acid gives a chromone. α-resorcylic acid and malic acid give a mixture of 5- and 7-hydroxy coumarins. Thus the α or 5-substituent has a profound influence on the Pechmann condensation, probably due to steric effect. It is therefore inferred that the known anomalous behaviour of orcinol in Pechmann condensation is also due to steric effect.

3. Dr. P. K. Bose, Calcutta.

Some recent work on natural flavones.

Flavones are a group of important colouring matters found in the plant kingdom, and of all natural pigments, they are the most widely distributed in nature. The scientific investigation of these colouring matters dates from the patient study of quercetin and fisetin by Herzig (1884). The structure of fisetin was established in 1891 by Herzig and that of chrysin by von Kostanecki in 1893. From 1895 onwards a considerable number of yellow pigments has been examined, and many of these have been found to belong to the flavone group of natural pigments.

Chemically speaking, flavones are 2-phenylchromones having the basic ring system (I), and are related to other natural products such as flavonol (II), flavanone (III), isoflavone (IV) and anthocyanins. Although a large number of flavone derivatives is known to occur in plants, either in the free state or as glycosides, the parts which they play in plant metabolism or in nature's economy are not definitely known.



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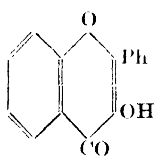

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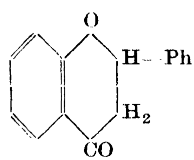

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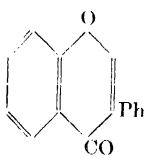
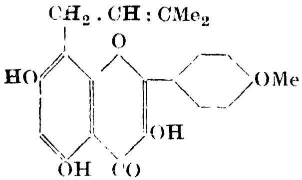


(IV)

Most of the natural flavones belong to the types (I) and (II). They are as a rule hydroxy derivatives or their methylated products. The number of such substituents in the phenyl residue does not exceed 3, whereas those in the benzopyrone nucleus may vary from 0 to 5.

Some interesting and new types of flavones have been recently discovered. Thus the flavone of tangerine oranges, called tangerine, has been shown to be 3: 5: 6: 7: 4′-pentamethoxyflavone (Nelson, *J.*

Amer. Chem. Soc., 1934, **56**, 1392; Goldsworthy and Robinson, *J. Chem. Soc.*, 1937, p. 46) The peels of Chinese mandarin (*Citrus nobilis*, Lour.) contain nobiletin which is probably 5: 6: 7: 8: 3′: 4′-hexamethoxyflavone. It is noteworthy that besides these two, no other fully methylated hydroxy-flavones have as yet been found to occur in nature (Tseng, *J. Chem. Soc.*, 1938, 1003; Tseng and Robinson, *J. Chem. Soc.*, 1938, p. 1004). Anhydroicaritin, the colouring matter of *Epimedium macranthum*, has been shown by Akai and Matsukawa (*J. Pharm. Soc. Japan*, 1935, **55**, 705, 719) to have the structure (V). It contains a dihydroisoprene unit as a side chain, and the compound furnishes the solitary example of a flavone containing the modified isoprene unit.



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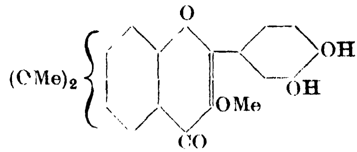

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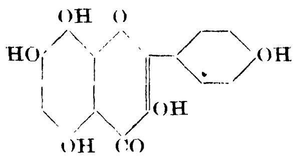
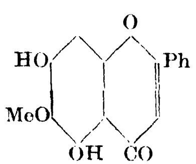


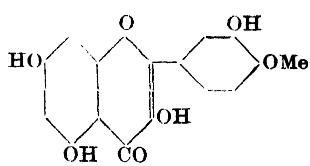
(VII)

Of lato, considerable amount of work has been done in India on natural flavones, and some new types of flavones have been isolated and examined. Thus, to amarbelin, the colouring matter of *Cuscuta reflexa*, has been assigned the partial formula (VI) by Agarwal (*J. Indian Chem. Soc.*, 1936, **13**, 531). Seshadri and his co-workers have isolated from Indian cotton flowers, a yellow pigment, named herbacetin, which has been shown to possess the structure (VII) (Neelkantam and Seshadri, *Proc. Indian Acad. Sci.*, 1937, *A*5, 357; Goldsworthy and Robinson, *J. Chem. Soc.*, 1938, p. 56).

The root-bark of *Oroxylum indicum* has been found to contain baicalein and oroxylin-A, which is the 6-methyl derivative of baicalein (VIII) (Shah, Mehta and Wheeler, *J. Chem. Soc.*, 1936, p. 591), whereas the stem-bark of the same plant contains, besides these two pigments, chrysin (Bose and Bhattacharya, *J. Indian Chem. Soc.*, 1938, **15**, 311),



(VIII)



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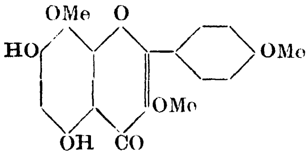
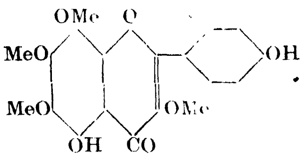


(X)

Desai has proposed the structure (IX) for the flavone, which he has isolated from the flowers of *Thevetia neriifolia* in the form of its glucoside (*Proc. Nat. Inst. Sci. Ind.*, 1939, **5**, 261).

Tambulin, the pigment of *Zanthoxylum acanthopodium* DC is a dihydroxy-trimethoxyflavone (Bose and Bose, *J. Indian Chem. Soc.*, **1939**, **16**, 183). Since dimethyltambulin has recently been found to be identical with pentamethylherbacetin, tambulin is (X). Of special interest are the colouring matters of *Calycopteris floribunda* and *Blumea eriantha*, named calycopterin and erianthin respectively. The former has, according to Shah, Venkataraman and Virkar (*Proc. Indian Sci. Congress*, 1941, Abs. p. 90), the structure (XI). The constitution (XII) has been proposed for erianthin by Bose and Dutt (*J. Indian Chem. Soc.*,



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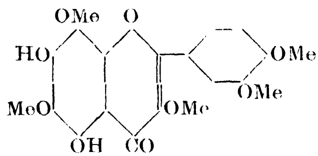
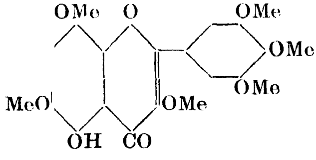
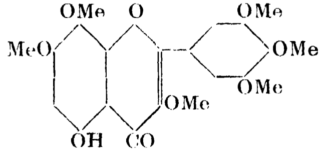


(XII)

1940, **17**, 45). These two compounds are derivatives of pentahydroxybenzene, and the benzopyrone nuclei possess the maximum number of substituents, namely five. Gardenin, the pigment of *Dikamali* gum (*Gardenia lucida*) has been examined by Bose and Nath (*J. Indian Chem. Soc.*, 1938, **15**, 139) who advanced two alternative formulae (XIII) or (XIV) for the flavone. The former structure is now preferred because one of the degradation products of gardenin, which is a quinone, has many



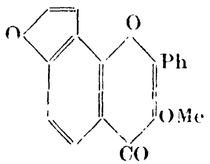
(XIII)



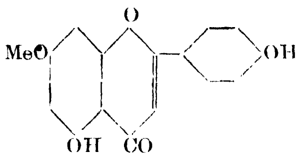
(XIV)

points of similarity with 2: 5-dihydroxyquinone. It should be mentioned in this connection that erianthin and gardenin contain as many as seven substituents and with the exception of these two compounds, no other representatives of heptahydroxyflavones, whether natural or synthetic, are known.

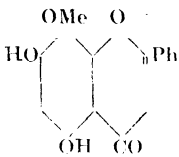
Pongamia glabra contains a furo-flavone named karanjin. It has been extensively investigated by Limaye and his co-workers (*Proc. Indian Sci. Congress*, 1925, 118, and subsequent papers) as also by Manjunath *et al* (*Ber.*, 1939, 72, 93) and by Rangaswami and Seshadri (*Proc. Indian Acad. Sci.*, 1939, 9, 259). It has the formula (XV). Genkwanin (XV)



(XV)



(XVI)



(XVII)

has been synthesized by Mahal and Venkataraman (*J. Chem. Soc.*, 1936, p. 569) and wogonin (XVII) by Shah, Mehta and Wheeler (*J. Chem. Soc.*, 1936, p. 1555).

4. Dr. D. Chakravarti, Calcutta.

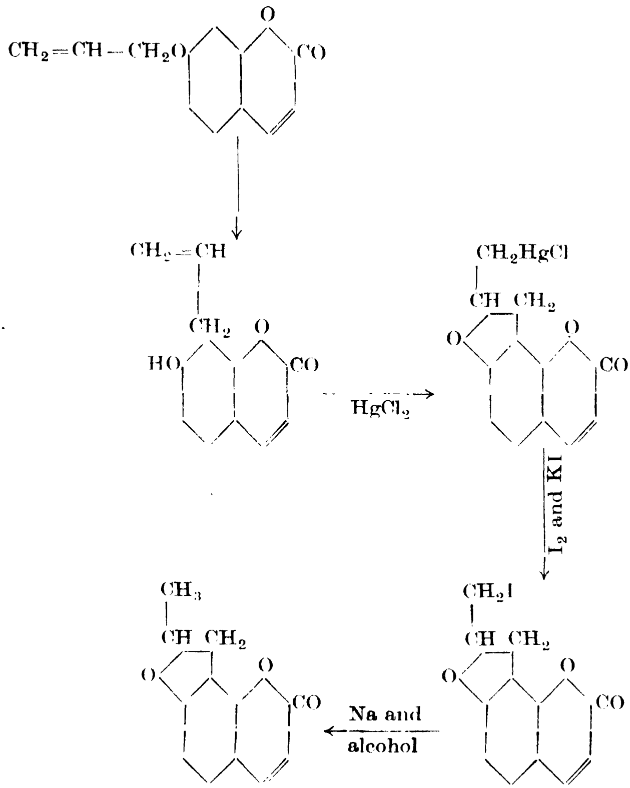
Synthesis of coumarins and chromones.

The limitations of Simonis' reaction have been discussed, pointing out the generalization by Chakravarti regarding the formation of chromones by Simonis' reaction. The limited applicability of Kostanecki's reaction, as studied by Heilbron, Chakravarti and others, has been briefly dealt with. Finally the method for the synthesis of coumarin, as developed by Chakravarti and co-workers, is fully discussed. Much stress has been laid on this new synthetic method and it has been pointed out that while the *o*-methoxy-aceto- or propiophenones on condensation with the α-halogenated fatty esters according to Reformatsky's method give rise to the unsaturated esters, which are easily cyclized to coumarins by heating with hydriodic acid or keeping in the cold with concentrated sulphuric acid, the *o*-methoxy-aldehydes, on the other hand, lead by the same series of reactions to *o*-coumaric acid derivatives, which defy cyclization to the coumarins.

5. Dr. T. R. Seshadri, Waltair.

Emphasized the importance of the naturally occurring coumarino- and flavonofurans as drugs and as insecticides and indicated the division of these and their derivatives into three groups, (1) 7-OH coumarin and 7-OH flavones with venyl groups in the ortho position, (2) 7-OH coumarins and flavones with allyl groups in the ortho position, and (3) 7-OH coumarins and flavones with isoprenyl groups in the ortho positions.

Described a method of preparing the second type given above which may be represented as below:



Similar series have been obtained from 7-OH flavones. Indicated a method of comparing their toxic properties using fresh-water fish and the interesting features of the study of the correlation of the toxic properties with chemical constitution.

6. Dr. N. M. Shah, Ahmedabad.

The rôle of condensing agents in coumarin synthesis.

The use of aluminium chloride in coumarin synthesis in changing the course of the Pechmann reaction was discussed. It gives otherwise inaccessible 5-hydroxy coumarins; whereas other condensing agents give the usual 7-hydroxy coumarins.

In this connection other condensing agents, viz. phosphorus oxychloride, phosphorus pentoxide, and sulphuric acid, were discussed.

The effect of α-substituent in the β ketonic ester in the synthesis of coumarins was also referred.

The condensation of 4-acyl resorcinols which does not take place in presence of sulphuric acid is easily affected by aluminium chloride with the production of 5-hydroxy-6-acyl coumarins. This reaction has been

extended to various 4-acyl resorcinols. The mechanism of the reaction was explained in terms of the chelation between —OH and —CO.R, which brings about the reactivity in the unusual γ-position of resorcinol molecule.

VIII. UTILIZATION OF INDIA'S MINERAL RESOURCES.

(Sections of Geology, and Geography and Geodesy.)

DR. M. R. SAHNI, Calcutta, presided.

1. DR. J. A. DUNN, Calcutta.

It is the work of the geologist to advise on the supply of minerals, and of the metallurgist, chemist and industrialist to advise on their utilization.

India's mineral resources, as in other countries, are not enormous, except in the case of iron-ore. Mistakes in mining and utilization have been made in the past in India, as in all other countries. It is part of the work of a Government official to reduce errors in the future. I shall discuss this subject as a series of recommendations.

(1) All mineral rights should preferably be vested in Government. In zamindari land royalties and surface rents accrue to the zamindars. Frequently mineral rights in zamindari land are split into innumerable shares and resulting litigation often hinders mining. In zamindari land the incentive is often towards quick returns and cheap mining, with consequent loss of reserves and a brief life to the mine. On the other hand, excessive royalties may force miners into liquidation.

Hence, from the point of view of the State, continuation of the vesting of mineral rights in zamindars is not to the ultimate advantage of either future industrial development or the conservation of mineral resources within the State.

(2) Government is entitled to an increased share in the profits from minerals in *khas mahal* land. The Provincial Governments obtain royalties and rents from the minerals mined; the Central Government levy a tax on profits and on the wages and salaries of those engaged in the industry. The amounts of the royalties and rents charged should depend on several factors; the object, in principle, is to secure the maximum revenue to Government which will not, however, bear unduly heavily on the miner and prevent him from efficiently working the mineral deposit. Early in the history of an industry the royalties should be low to encourage development, but once the industry is firmly established it is legitimate to raise them within reason. Increased royalties and rents help also to eliminate the inefficient miner with little capital, tend to conserve resources and reduce waste, and tend to reduce lease areas to a minimum and thus reduce damage of forests.

(3) There should be some restriction in the granting of leases. The maximum value is obtained from minerals by manufacturing them into finished articles in India, rather than by exporting them. For example, I would advocate reserving all the manganese deposits of Singhbhum and Orissa States for the iron and steel trade, as they are more accessible than the Central Provinces ores. In Singhbhum and Orissa States manganese leases should be granted preferably to steel companies or to such local users as manufacturers of dry batteries. Again, certain deposits should never be leased for mining. For example, the mining of deposits of float iron-ore, or iron-ore debris, destroys forest areas and does more damage than such ore is worth: there are enormous reserves of solid or

bedded iron-ores to which iron-ore mining should be restricted. Mining technique is better developed by large companies with plenty of capital than by small concerns with little financial backing; in the interests of the best development of the country's resources leases should preferentially be given to large companies. Small concerns would still find scope in such resources as road metal and railway ballast, building stones and small gold veins. The mining of certain deposits may be even better held up for a while until related industries which can use the minerals in the country are developed.

(4) The domestic treatment of India's mineral raw materials should be expanded. To the rest of the world three Indian minerals are important: mica, ilmenite and manganese. For these there is no large domestic market and export of them must continue. But every endeavour should be made to manufacture, in India, micanite, titanium dioxide and increased amounts of ferromanganese. Iron-ore resources in this country are so vast that export of this ore always will be advisable providing a market can be found. The development of industries from other minerals will depend on the market's capacity to absorb the products and on cheap power. Industries tend to segregate in Bihar and Bengal. If other provinces wish to attract mineral industries they should endeavour to provide cheap power. Certain provinces have mineral resources, and are unable to compete with Bihar, but cheap power would encourage local manufacture.

(5) Prospecting should be stimulated. The granting of a small bonus by Government for finding new deposits of commercial value might encourage a mineral sense amongst villagers.

(6) The wider use of certain minerals should be investigated. Some examples—the manufacture of abrasives, mineral paints, mineral wool, and sulphuric acid, of bichromate and ferro-chrome alloys from chromite, and vanadium alloys from vanadium deposits; the wider use of barytes, phosphates, bauxite, steatite, mineral waters, and sillimanite and kyanite.

(7) Statistics of mineral production should be complete. Usually only those mines which come under the Mines Act submit returns of production. Small mines, particularly on zamindari land, usually submit no returns. It should be compulsory for all miners to submit returns annually to district officers in States and Provinces for them to be forwarded to a central body such as the Geological Survey.

(8) A Bureau of Mineral Information should be established. It would be the centre for dissemination of information on minerals in India, and would issue statistics and bulletins. It would have a small permanent staff, whose duty it would be to make a life study of Indian economic minerals. It could work within the building of the Geological Survey. It could even be the administrative body for a Mineral Research Laboratory.

(9) There should be closer co-operation between Government, Industrial and University geologists. Each has his own sphere of work, sometimes there is unnecessary overlapping, but each can give the other invaluable assistance, especially as there are so few geologists in India.

2. Dr. S. K. Roy, Dhanbad.

Though various branches of this subject namely ceramic research, fuel research, soil research, etc., are given prominence in the research fields of India, mineral research in general is not getting the necessary prominence.

Mineral research can fall into the following three sub-heads:—

(A) Mineral researches of immediate industrial importance.
(B) Researches which are of no immediate industrial importance but the results are expected to be useful to the mineral industry in the near future.
(C) Mineral researches of scientific and cultural importance.

A.

Under the first group the following may be included:—

(1) Researches on mineral paints—ochres, hematite, chromite, manganese ores, baryte, lead ores, silica, gypsum.
(2) Researches on minerals used in the ceramic industries; glass sand and various glass batches; enamels, myolica, porcelain and earthenware manufacture.
(3) Researches on Indian refractories; China clay, ball clay, fire clay, graphite, silica, kyanite, bauxite, asbestos, zircon, chromite and magnesite; researches on the construction of ceramic crucibles and ceramic ovens.
(4) Fuel research (coal and petroleum).
(5) Standardization of lime.
(6) Manufacture of sulphur from sulphur dioxide gas.
(7) Researches on the marble and decorative stone resources.
(8) Researches on minerals used in the Paper Industry.
(9) Researches on the extraction of beryllium, aluminium, etc., by electrolysis.
(10) Researches on the extraction of vanadium, tungsten, tantalum, cerium and other rare earths and their salts from their respective Indian ores.
(11) Researches on mica and micanite; manufacture of motors and dynamos in India from Indian raw materials.
(12) Rediscovery of the deposits of diamond, zinc ore, cobalt ore, and other minerals known to the ancients.
(13) Soil research; soil profile; soil survey.
(14) Researches on the metallurgy of Indian ores—bauxite, chromite, manganese ores, iron ores, copper ores, nickel ores, cobalt ores, bismuth ores, lead-silver ores.
(15) Resurvey of the placer gold deposits according to the modern methods.
(16) Research on the various properties and uses of asbestos found in India.
(17) Researches on salt and saltpetre deposits in India.
(18) Investigation on mineral manures found in India; researches on the phosphate deposits and rocks rich in phosphorus found in India with a view to ascertain their values as manure; saltpetre deposits, etc., etc., etc.
(19) Researches on mineral abrasives.
(20) Properties of Indian building materials—laterite, sandstone, limestone, marble, granite, basalt, gneiss, slate.

B.

(1) Geophysical researches; torsion balance survey of the Indo-Gangetic Plain for petroleum; radioactive survey for underground water in Rajputana, etc.
(2) Researches on the mineral and medicinal springs of India; radioactive springs.
(3) Researches on the underground water resources of India, geological as well as geophysical.
(4) Researches on the pebble and sand beds suitable for reinforced concrete work and road metal for heavy traffic.
(5) Researches on clay beds—pipe clay, brick clay, etc.
(6) Researches on the suitable sites for hydro-electric power station in our country, etc., etc., etc.

C.

(1) A systematic crystallographic study of the crystals of Indian minerals.

(2) A systematic study of the piezo-electric and pyro-electric minerals found in India.
(3) A systematic chemical and physical study of the rocks of India.
(4) A systematic study of the Indian ore minerals under ore microscope.
(5) A systematic study of the Indian coals under the ore microscope.
(6) History of Indian Mineral Industry as can be determined from Kautilya-artha-sastra, Ratnakaram, Manimala, Rasaratna Samuchaya, Aini Akbari, Hindu chemistry, and Tibetian Literature in which all our ancient literature has been translated, etc., as well as recent publications.

3. MR. N. N. CHATTERJEE, Calcutta.

Meaning and scope of ' Utilization '.

According to the author the underlying principle of '*proper utilization*' should always be to take the country's welfare and the total ore reserve into account. Proper utilization of minerals should always be guided by the modern scientific knowledge. Simple production and consumption of minerals do not mean that efficient utilization has been effected. Sufficient importance should therefore be laid on limited mineral reserves and their proper and efficient utilization.

To effect proper utilization the various physical and chemical characters of coal and other economic minerals should be definitely known.

The author has reviewed the present-day conditions in India which he considers to be yet unhealthy and unfavourable for efficient utilization of economic minerals. For example coal which was discovered in 1774 is not properly utilized even now and the malpractices have often been criticized and condemned but with very little effect. Other examples may be cited.

A national mineral policy wanted.

In order to initiate and encourage proper and healthy development of mineral resources of this country the author suggests that India should have a national mineral policy and that there should be a central organization like the National Research Council of other countries The Government has recently started a Board of Scientific and Industrial Research as war-time measure to encourage development of industries in this country. The author suggested that this war-time industrial measure should ultimately be made permanent and should be based on national mineral policy. According to this policy the Government should continue to encourage further development of mineral industries giving due attention to the aspect of proper utilization of raw materials and should assure help and protection to these industries during normal peace time against foreign competition.

In order to initiate a series of investigations on coal and other economic minerals there should be under this Central Board of Scientific and Industrial Research two separate research stations, directly under the respective expert Boards, namely:—

(i) Fuel Research Board, and
(ii) Mineral Research Board.

(i) *Fuel Research Board.*

As regards the constitution of these Boards it was suggested that non-official experts with sufficient experience should also be co-opted.

The Fuel Research Station should be located at the Alipur Test House where necessary equipment and staff are already existing and further

expansion may be made at a moderate cost. Assaying and testing of various types of coal on all its aspects should be carried in this laboratory. The author has suggested that the question of producing cheap gas and electrical power from low grade coals should now engage the attention of the industrialists in all seriousness. This cheap gas may be easily transported to some distance to supply the needs of various industries and synthetic petrol plant may also be erected to obtain oil from water gas. As the advantages of pulverized coal firing of the low grade high volatile coals are already known, the owners of the locomotives and other steam raising plants should start immediately to modify their boilers to feed pulverized coal. This will surely stop the wastage of the high grade metallurgical coal. The question of improving the method of soft coke manufacture by introducing simple chamber ovens, with recovery of by-products, should not be put off any longer as it is already overdue. These are some of the important uses of coal, and steps should be taken by the State and the coal industry to give immediate effect to these applications which are expected to give longer lease of life to the coal resources of India.

(ii) *Mineral Research Board.*

The Mineral Research Station should be allowed to develop in the Geological Survey of India laboratory and the important properties of ore and gangue minerals should be studied in each individual case. Experiments should be conducted in each case to improve the economic minerals by methods of concentration, washing and purification, etc. Such information when published in the form of a cheap bulletin, will go a long way in helping the enterprisers in the respective lines. In order to tackle all sorts of problem, the present staff of the G.S.I. would seem to be inadequate and the Government may be moved to expand the department accordingly.

State control necessary.

In this way sufficient information and data would be forthcoming to guide the industry and the trade in the matter of proper and efficient utilization and educating them to avoid wanton wastage of mineral resources which are very limited in many cases. Government should discourage malpractices of utilization and in the matter of wastage it would be necessary for the State to intervene and stop it by law. The export of raw materials should be condemned and discouraged wherever possible and local industries should spring up under the care and protection of the State. Following examples may be cited: bauxite, ilmenite, manganese ore, etc.

Central Marketing Board.

There should be a permanent Central Marketing Board for the growth of the domestic industries and this Board should be in constant touch with the Central Board of Scientific and Industrial Research to chalk out specifications and marketing possibilities. This Marketing Board should receive sympathy and support of the State.

Conclusion.

In conclusion it is hoped that the Government will give this discussion a careful consideration. A successful functioning of the scheme outlined above will effect *proper utilization* of the raw materials which should be the underlying foundation and structure upon which the development and growth of mineral industries will depend. This procedure will lead

to conservation of India's mineral wealth for the welfare of the present as well as the future generations.

4. Dr. H. K. Mitra, Jamshedpur.

(1) The subject under discussion touches life at so many points that I am not surprised at the manifestation of some uncommon phenomenon that we have witnessed this morning. For instance, we find Dr. Dubey, a student of science, receding in the domain of politics and making the preposterous suggestion that we should do away with research in India. Dr. Dunn, the geologist, spoke almost like a socialist when he brought out his first three points, which sounded like an advocacy for nationalization of mineral wealth. It has been suggested by another speaker that whatever mineral resources in India we cannot use in this country at the moment, should preferably be exported. To even a casual observer, it is apparent that there is something radically wrong somewhere which makes it possible for many of India's vital mineral resources go out of the country only to be returned in the form of finished goods. I wonder why instead of advocating the sending of raw materials away, the establishment of industries to utilize these resources is not suggested. It is apparent that we have to see that such resources are not exhausted by exporting them, otherwise when the necessary industries are established in this country, we will be threatened with shortage of the needed raw materials. We must therefore take immediate steps in a systematic way to prevent unnecessary exportation of these materials. This brings out the question of National Planning. We have no doubt that the National Planning Committee is devoting its attention to such problems. A previous speaker has suggested that the recommendations of this Committee cannot be given effect to till we get more power into our hands. I ask 'Shall we sit with folded hands till the assumption of such powers ?'

(2) With reference to your remarks, Mr. President, about the desirability of having a Mineral Research Organization started with the Laboratory of the Geological Survey of India at Calcutta, as a nucleus. I see no objection to such a proposal especially as we have such eminent persons who participated in this morning's discussion in that laboratory. But I ask why they alone should have the monopoly of such research. You have mentioned, Mr. President, about the Batelle Memorial Institute and the Melon Institute of Industrial Research in U.S.A.—institutions which I had the opportunity of studying at close quarters several years ago. I may make mention of similar institutions like the Engineering Experiment Stations of the State-Aided Universities of U.S.A., which are engaged on work similar to what you are advocating. I do not see why the Benares Hindu University, or for that matter, the various universities of India, cannot start similar institutions in this country to take up not only mineral research work but other similar work of industrial importance.

(3) Let us not wait for the time when we will be in power to give effect to the recommendations of the National Planning Committee. It does not take much intelligence to understand what vital mineral resources should be conserved for our immediate or future use. With the talents that are available in this country, let us carry on necessary investigation work on these and other allied fields—in semi-plant scale, if necessary—in the many institutions that are already in existence in India. Above all, let us work and right now.

5. Mr. C. Mahadevan *and* Mr. Syed Kazim, Hyderabad-Deccan.

In any scheme of planned industrialization the preliminary requisites are a thorough appreciation of the actual available mineral resources in different parts of the country. Basic, or key industries should be located at sites commanding best resources of raw materials and easy access to

markets, such industries should be complementary to one another and duplication should be avoided. Taking the present mineral production as a working basis, the country is divided into different units for specialization in distinctive industries. Indiscriminate attempts to initiate industries on irrational methods is highly deprecated. Conservation of mineral resources to serve the country's growing industrial needs is considered an urgent necessity.

6. Dr. Kazi S. Ahmad, Aligarh.

I have heard very carefully the learned discourses of the preceding speakers. What is striking is that very little has been said about how far our mineral resources can be utilized to develop an industrial structure in this country to be able to compete with foreign competition.

No attempt has been made to analyze the distribution of minerals in relation to the facilities for their utilization and exploitation. One should like to know how far their location is helpful to economic exploitation. It would be interesting to find how the difficulties in the way of their utilization can be overcome.

An important question is how best India's resources can be utilized to eliminate the foreign goods which take away a large amount of capital from this country which could better be utilized for the uplift of this country.

Another question is to evolve a scheme by which the mineral corporations, railways and manufacturing concerns could best co-operate for the efficient utilization of the resources of this country.

There is a large amount of dead capital in this country. Means, should be devised to attract this capital to help in the exploitation of our mineral resources and building up our mineral industries.

7. Mr. K. N. Bhattacharya, Calcutta.

I agree with the previous learned speakers that for the advancement of learning and industry research works are necessary but they should always be on genuine scientific spirit. I specially thank Dr. Fox for mentioning some difficulties in the field.

Very often nowadays we come across geological and mineralogical articles published in popular daily newspapers, giving fantastic ideas regarding the prospecting of minerals and fancy imaginations of utilizing the probable mineral resources, which perhaps can never be exploited. These modern scientists think still in the classical ways that Geology is a subject like German which is understood by a few. Some geologists think to-day of prospecting copper in the inaccessible peaks of the Himalayas; perhaps his speculative research spirit will some day lead him to prospect gold from the alluvial soil of the Indo-Gangetic plain or to throw off the Deccan trap into the Arabian Sea to dig the Gondwana coal or to extract iron from dunite.

These fantastic schemes are certainly misleading and the geologists as a class specially the professional ones suffer. For a first few occasions they may win popularity that may be cheap but that can never stand for long.

Under these circumstances I request the Geology Section of the I.S.C. to see into the matter and enlighten the public in the subject and save them from misleading conception and extra taxation in these hard days of war and economy.

IX. PRACTICAL STEPS TOWARDS THE IMPROVEMENT OF MUSEUMS IN INDIA.

(Sections of Geology, Anthropology and Botany.)

DR. M. R. SAHNI, Calcutta, presided.

1. MR. L. S. KRISHNAMURTHY, Hyderabad-Deccan.

Aims of Museum Organization.

In India the maintenance of museums is limited to some of the Provincial Headquarters and Capital cities of the Indian States. This fact naturally limits the general utility and educative value of the museums to the fortunate few to whom it is in easy reach. The fundamental principles of museum organization should be to afford an easy access to all who seek it. Its aim should be of a comprehensive nature for practical suggestions on such subjects like agriculture, raw materials, mineral resources, trade possibilities, sanitation, education and public health, archaeology, arts and crafts. A separate section of the museum should be devoted to the economic utilization of local resources.

Central Museum with co-ordinated smaller Units.

A central museum in the Provincial Headquarters would not be adequate. It should be co-ordinated with smaller units like the District and Tahsil museums. The establishment of such museum units in each District, and preferably also in each Tahsil, would go a long way to make the museum organization more popular, easily accessible, instructive, and useful. A central Provincial or State Museum should not only include all the exhibits of the District or Tahsil museum units, but also bring into its sphere such important themes of public interest as would affect the economic, civic, and educational advancement of the State or the Province as a whole.

Technical Departments to be adequately represented.

In addition to the maintenance of their respective comprehensive departmental museums, technical departments, like Geological Survey, Mines, Archaeology, Agriculture, Commerce and Industries, and the University, should co-operate with the Central Museum. The full scope of the activities of each department should find adequate representation in a popular manner with suitable exhibits and proper charts to make the section interesting and easily understandable by a layman.

Scope of Museum.

Each museum should represent mainly indigenous products with very little space devoted to foreign exhibits, unless the latter are needed for comparative study or for any other specific purpose.

The economic exploitation of agricultural and forest products, mineral resources and other raw materials, should form an interesting and educative theme in the Museum technique. Not only the available raw materials should be exhibited, but also the finished products which could be manufactured and the by-products if any from the respective raw materials. Resources for either a cottage industry or for big scale industries should receive their legitimate representation. All information regarding economic data with charts and suitable illustrations, and

marketing facilities should be furnished wherever possible in an easily available and popular digest.

Administration of Museum Organization.

The formation of the Central Museum with its respective District and Tahsil units, should be under the guidance of an active 'Museum Advisory Committee' in which all the major interests are represented by responsible men. The actual work of organization of the Museum should be in the charge of an officer who is familiar with up-to-date Museum technique and has studied many of the Indian and foreign museums and their working.

The various District and Tahsil museum units should be under the supervision of the respective heads of the District or Tahsil, guided by the Museum Advisory Committee, with the Chief Museum Officer as its Secretary.

Efforts to increase the Cultural and Educative Value of Museums.

It may be pointed out that museums, as they are to-day, evoke very little of lively interest. They are like curiosity shops. People, when they visit a museum, generally come back not very much wiser. They see only a varied collection of extraordinary exhibits without being able to appreciate their real significance and value.

A museum should be organized in such a way as to make it into a living institution, where people can really see things in their proper perspective and acquire desirable knowledge of things around them. The educative side of the organization should be kept foremost to create an interest in the public. For this purpose, periodic demonstration lectures aided by motion pictures on the screen on various subjects of popular, scientific and economic interests should be actively pursued. This should not be limited to the Central Museums, but also form a periodic programme of the smaller units.

Conclusion.

In conclusion, it may be added that an active co-ordinated Museum Organization is an immediate necessity not only for its immense educative value, but also for popularizing in a simple but effective manner the economic, industrial, civic and cultural life of the country.

2. MR. N. N. CHATTERJEE, Calcutta.

The following suggestions are made for improvement of the geology section of the Indian Museum, Calcutta:—

Ground Floor:

1. (*a*) In the Siwalik Gallery more pictures and restorations on evolution of animals in India should be displayed.
   (*b*) Restoration in clay models may be locally made under the guidance and supervision of the Curator.
   (*c*) Brief explanatory notes should accompany such diagrams and restorations and their range should always be indicated in years.
   (*d*) It should also be clearly stated if the animals are still existing or have become extinct.
   (*e*) Distribution of land and water in India at different geological periods should be exhibited in coloured diagrams with short account of geological history.

(*f*) Restorations of different ape men and primitive men should be exhibited to supplement the useful chart that has recently been displayed to show the evolution of man.

2. There should be many pictures and photographs on various topics of physical geology, structural geology, mountain building, interior of the earth, etc. Some block diagrams if exhibited will be very useful to the visitors.

3. *Meteorites:*

(*a*) Indian falls should be placed in a separate glass case to create greater interest amongst the people.
(*b*) A map of India showing the localities should also be prepared and placed here.
(*c*) Weights of the meteorites should in all cases be given in Indian measure.
(*d*) Foreign collection should find place in another glass case with a map of the world showing the localities.

4. The existing specimens in the glass cases showing sedimentary, igneous and metamorphic rocks are all foreign. They should be replaced by Indian specimens as far as practicable. This step will help the younger generation to be more familiar with the local rocks and minerals. The rock specimens should be arranged according to petrological classification and not according to stratigraphy.

5. (*a*) An up-to-date mineral map of India on a large scale should be placed in the Economic Mineral Gallery.
(*b*) Provincial mineral maps should also be displayed as economic minerals of the provinces are now exhibited separately.
(*c*) Geological maps of separate provinces should be prepared and displayed in their respective places. Maps of the Provinces should be on the same scale.

6. (*a*) Indian stratigraphy has been split up and displayed according to Provinces. Geology knows no political boundary and by the display of Indian stratigraphy in this artificial way the same rock types and specimens have in many cases been repeated and unnecessary duplication has thus been introduced and valuable space has been wasted. On account of this arrangement even the serious students of geology are confused to follow systematically the proper sequence of Indian stratigraphy. It is therefore highly desirable that the stratigraphy of India should be arranged according to different geological horizons. Separate facies of deposition during the past periods should also be given due importance.
(*b*) Some clay relief-models showing physical conditions of India during the past geological epochs will be very much appreciated by all classes of visitors.

First Floor—Fossil Gallery:

7. This gallery is the one which attracts very few people either literate or illiterate excepting of course the serious scientific workers.

(*a*) The author likes to suggest that some diagrams and clay models demonstrating stories of evolution of plants and animals should be displayed in this gallery. The environmental physical features by diagrams and models would also be very much appreciated by the visitors.
(*b*) A brief geological history should be given in each case.
(*c*) Before concluding the author would like to make special reference to the wall cases and the fossil specimens therein.

The duplicate specimens for storage may be removed from the wall cases and be housed in drawers elsewhere and specimens of interest should only be displayed here. The author suggests that the wall case should be remodelled, reshelved and rearranged so that all the specimens may be well within the scope of examination by the interested visitors. The galleries should be made accessible at the top. A balcony with railings should be provided for with small stairs at each end. By this arrangement sufficient accommodation will be available for exhibiting more specimens and restoration models.

(*d*) A chart showing general classification of plant and animal fossils together with their range in geological time may be exhibited at a suitable place. Evolution charts when displayed will complete the equipment.

3. *Provincial Museums :*

In provincial museums the stratigraphy of the particular Province should be exhibited in sufficient detail. Economic mineral specimens and a mineral map of the Province on a large scale should find an important place there. This will infuse greater interest amongst the people of the Province. Diagrams, charts, models, etc., should be profusely displayed for the purpose of demonstrating various features of the Province.

If the above suggestions are given favourable consideration by the authorities concerned the huge collection that is already in the Museum galleries will continue to serve its useful purpose and will spread and diffuse knowledge amongst all classes of visitors regarding India's past geological history, thereby fulfilling the object for which museums are maintained by the public fund.

3. MR. A. G. JHINGRAN, Calcutta.

General.

1. Each set of exhibits must bear a large label describing the main feature of the collection. Headings such as 'The Economic Minerals of India', 'Agricultural Products of India', etc., should be fixed at prominent places.

2. Labels giving brief introduction to the subject pertaining to the exhibits in a gallery must be placed at the entrance to each gallery or a big section. For instance at the entrace to the fossil gallery there must be a label describing the term fossil and explaining how fossils are preserved and what they mean to show. In the absence of such a label the entire fossil gallery means little to all but those few who have learnt something of Palaeontology. Similarly at the entrance to a gallery exhibiting the collection from Mohenjodaro excavations there ought to be a label giving the location of Mohenjodaro and the significance of the collection, and so on.

3. The labels attached to the individual exhibits should, as far as possible, not consist of mere names but should describe the salient features, such as may excite interest and curiosity to know more. For example the label attached to the Egyptian Mummy must be detailed enough to explain what the exhibit is.

4. The labels must, of course, not be written in English only. Indian languages should be given their due importance. In the Provincial Museums the respective provincial languages ought to be used, and in an All-India Museum attempt must be made to use three or four of the most common languages such as Hindi, Urdu and Tamil. Care must be taken that the translations rendered into these Indian languages are done precisely and also written correctly.

Geology Section.

The following sets of exhibits should find a place in the Geological Section of the Museums.

1. Set showing the minerals being raised in the respective provinces, thus the Museum in Lucknow ought to have a set of minerals being raised in the United Provinces, and the Museum in Nagpur ought to have a set of minerals being raised in the Central Provinces, and so on.
2. Set of minerals being raised in India.
3. Set of mineral raw-materials needed for some of the common industries such as (1) paints and varnishes, (2) cement, (3) pottery, (4) glass, (5) heavy chemicals, (6) iron and steel, (7) aluminium, (8) armament, etc.
4. Set of minerals used for various industrial purposes such as (1) refractories, (2) adulterants, (3) paints, (4) insulators, (5) lubricants, etc.
5. Set of minerals which are extremely valuable for the development of industries, but which are not found in India and which have got to be imported from abroad. In such a set the labels attached to the exhibits should describe the uses to which the particular mineral is put, the country or countries from where the mineral is imported, the average amount of annual import, and if possible also indicate the places where the mineral is likely to be found in India. Such a set will give an impetus to prospecting work for such minerals as are yet not reported to have been found in India in economically workable quantities.
6. Graphical and pictorial charts showing the growth of mineral industry in the various provinces and the country in general.

4. MR. M. N. BASU, Calcutta.

In proportion to its population India is still far behind the advanced countries of the world in Museum Institutions. The author is particularly concerned with Bengal. Agriculture and Pisciculture are the main industries of Bengal, which are being hurled into the abyss of destruction owing to the want of any proper knowledge of the thing. A museum will be of immense value to the people in general.

X. STANDARDS OF AGRICULTURAL PRODUCTIVITY.

(Section of Geography and Geodesy.)

DR. S. M. TAHIR RIZVI, Aligarh, presided.

1. MR. S. M. ALI, Aligarh.

Standard of Agricultural Productivity.

When you describe an agricultural region do you build up some idea of how fertile or productive it is ?

Or are you content to describe the type of farming practised, i.e. arable or grass, dairying or beef, large or small holdings, and so on ?

When you assert that a region is fertile, rich or productive, do you support your opinion by quoting any quantitative standards, e.g. high rents, land values, yields, etc. etc. ?

In the proposed discussion it is contended that:

(1) Since productivity varies widely from region to region it is desirable that some simple standard should be agreed upon

to facilitate description and comparison. (How do so many so-called productive regions compare? Is the Nile Valley as productive as the rice lands of Bengal? Or Java as central Belgium?

(2) No satisfactory standard of this kind exists.

The following questions were therefore raised:—

(1) Is a numerical scale of productivity desirable?
(2) Which would have the greater utility for geographers, a scale of actual productivity or one of potential (natural) productivity?
(3) Is either scale feasible?
(4) On what basis might a scale of actual productivity be evolved?

Other issues which arose were:—

(1) Which is the more important in determining (*not* ascertaining) actual productivity—
natural fertility *or* intensity of cultivation?
(2) Suppose an area which is fortunate in its climate and soil proves to have the same Productivity Index as inferior land which has been much more intensely cultivated—Is the productivity scale nevertheless useful?
(3) Is it possible to visualize a scheme to show the 'two dimensions' of productivity?

XI. PHYSIOGRAPHIC DIVISIONS OF INDIA.

(Section of Geography and Geodesy.)

DR. S. M. TAHIR RIZVI, Aligarh, presided.

1. DR. KAZI S. AHMAD, Aligarh.

Dr. Pithawalla has divided India into three major physiographic divisions, forty-four physiographic provinces with twenty-nine sub-sections. The chief criterion claimed to be adopted is that the principal divisions are made according to geology and topography (rocks, drainage, etc.) as controlled by the internal and external agencies working on them. The findings of the allied sciences, such as Botany, Zoology, Meteorology, are considered while making sections and sub-sections of major divisions.

Actually in his scheme of the physiographic provinces this basis has not been consistently followed and physiographic homogeneity often overlooked, for example the physiographic province (1) V, the Eastern highlands, covers a huge area to include the old plateau and the newly folded ranges of Assam and the whole of Burma, large areas so much diversified in structure and land-forms. If such areas can fall under one province, the whole of India can as well make one physiographic region. The criterion for the physiographic province (2) IV, Upper-Ganges Valley. and (2) V, Middle-Ganges Valley, is climate, irrigation, and cultivation. The regions have not been properly differentiated, located, and defined, The middle Himalayas province (1) II swings round to the north-west of India to include N.W.F.P. and Upper-Ganges Valley province is mostly located over the Ghaggar plain. Even some terms are not properly used. Kashmir Valley has been called a Dun Valley.

When the physiographic regions are carefully examined one fails to note much uniformity in their classifications except in a few cases. What is striking is a lack of unity in their individual entity. To be exact the scheme is examined below, division by division and province by province:—

The fundamental division of India into three parts, (1) Extra-Peninsular, (2) Indo-Gangetic Plain, and (3) the Peninsular area may be geologically correct but is not desirable from the physiographic point of view as the peninsular area includes two quite different regions, Coastal lowlands and Deccan plateau.

Division (1), Extra-Peninsular.

Province I. The sections A and B are not clearly and correctly defined. What is meant by anticlinorium valley ?

The classification of the Himalayas is not correct. The name 'Southern Himalayas' is given to an area which, according to his own terminology, lies to the north of the 'middle Himalayas'.

Province II, sections A and B. By what he calls 'The Northern Himalayan Section' he means the axis of the great or main Himalayan Range, as shown by the peaks named. It is composed mostly of crystalline and metamorphic rock-granites and schists, of unfossiliferous sedimentary beds, believed to be principally of palaeozoic age. It does not consist of highly fossiliferous sedimentary rocks. This is characteristic of the Tibetan section lying to the north of the main Himalayan Range.

The area put under section B, the southern Himalayan section, is not clearly intelligible.

Province III, section B. Kashmir Valley is not a Dun Valley. The position of the Dehra Dun is not relatively the same as that of the Kashmir Valley.

Section C. The name 'Himalayas proper' is not a proper choice. Perhaps the author means the lesser or lower Himalayan ranges lying to the south of the main Himalayan Range, which seldom rise much above 12,000 ft. to 25,000 ft. An emphasis on snow-line at 16,000 ft. may give a wrong conception of their height.

Province IV. The Potwar region is not properly demarcated. It is shown to extend eastwards across the Salt Range.

It is mistake to group it with the Swaliks. As shown on the map it is not a continuation of the Swalik section further west. The Swaliks are continued up to Indus and even beyond it. The Potwar region lies to the south of them and is different in conformation. The Swalik hills are not flat and not so low as only 300 to 500 ft. high. Their average height is 3,000 to 4,000 ft.

Province V. As mentioned above, under province V have been included large areas much varied in structure and land-forms. It is difficult to find any basis of unity in this extensive area to be combined into one physiographic region.

Division (2), Indo-Gangetic Plain.

Province I, section A. This section as shown on the map is too broad. A more or less similar type of region in the north-east of the Punjab has been neglected altogether. Drift soil is not characteristic of this section alone. The whole of the Indo-Gangetic Plain has drift soil. In what respects have the sand-belts or clay-belts been called rich ?

Section C. 'Many and frequent hydrographical changes' are unnecessary repetition.

Province III, sections A and B. The boundaries of Pat and Thar section require further explanation.

Province IV, sections A and B. The bounderies are not correct.

Section A is supposed to be Ganges-Jumna Doab but on the map it includes a large portion of the Ghaggar plain and has not the proper orientation. Similarly Pohikhand section (section B) is wrongly shown.

The difference between these two sections is just that of a few inches of rainfall which is not sufficient basis for division in such a generalized scheme as it is. Even much greater variations have been neglected. For example, the next region (2) V, middle Ganges Valley, extends across a much wider range of rainfall without its being further sub-divided.

Province V, middle Ganges Valley. It cannot be said for the whole of this region as demarcated that rice is more important than wheat.

Province VI, section C. The Damodar Valley is not in section C but in B. The boundary between section B, the old delta, and section C, the new delta, is not correct.

Division (3), the Peninsular area.

Province I, section B. It is not proper to call this Aravalli region as plain.

Section C. This section is shown on the map to extend eastwards, south of U.P. up to Bihar. So it is not desirable to put it under the general heading of Rajputana and uplands.

Province II, section B. The Western Ghats should not be confined to the region of the Deccan Lavas.

Section C. It is not proper to make an absolute statement that 'Bombay Deccan is thinly populated'. It is only relatively true.

Section D. Gujarat does not largely consist of the shore focii of the Western Ghats.

Province III, north-east foreland. The choice of the name 'foreland' is not a happy one, as this region has not separately functioned as foreland. It includes coastland and his emphasis is on river basins which cannot be called forelands.

Section C. It is not correct to confine the Eastern Ghats to the small area shown on the map.

Province IV. This province is entitled 'the southern plateau' but includes coastal lowlands.

Section A. It is not correct to say of Malabar as an alluvial plain. It may be pointed out that under province II, section E, he has referred Konkan as a plain of marine denudation.

It will be seen that the above criticism deals mostly with some mistakes of facts which have cropped up in the attempt to define the regions. It is difficult to improve on them as such.

The speaker then submitted an entirely new scheme.

2. MR. GEORGE KURIYAN, Madras.

Prof. Pithawalla has in his paper suggested a division of India into physiographic regions and has added that these physiographic regions should form the basis for further regional study. Dr. Ahmed has given an elaborate destructive criticism of Prof. Pithawalla's divisions so that there is absolutely no need for me to take up any more time on that score and Dr. Ahmed has given us, according to himself, 'a very simple scheme instead'. I for myself am not quite prepared to agree that the scheme given by Dr. Ahmed is either simple or a distinct improvement on that of its predecessor. If Prof. Pithawalla is criticized for 44 sub-regions, Dr. Ahmed's scheme, I wish to point out, does not fall far short of 35! And this is certainly not a distinct advance.

The main purpose of our discussions to-day is to find out the basis of a classification of India into natural regions. 'Man made divisions

for political and administrative purposes must occupy a most important place, but they can only be appraised in relation to entities, which, while they represent real distinctions, have not been deliberately created by man. The term natural is notoriously difficult to define, but is clearly opposed to political.' In our study of regions, we are concerned with the interaction between the physical and biological conditions on the one hand and the nature of the human response on the other and an attempt must be made to facilitate such studies in Indian geography.

Several factors have necessarily got to be chosen in effecting a division of India. Physiographic regions are admittedly important in that they are more or less permanent, but nevertheless they cannot in themselves be complete.

A major region like India is necessarily constituted by a harmonious but complex combination of many different elements, but the smaller regions within it are generally distinguished by the prevalence of some particular characters, revealing thus a concept of variety within unity. In a large country like India, it would perhaps be impossible to choose factors which have a universal application, but understanding is more important than classification.

I would like to suggest that geographic entities should be used as political provinces and our criteria then should be such that their location on the ground is not rendered particularly difficult. At the same time, such factors as languages, are fundamental. Linguistic affinities are more important than communal and I am availing of this opportunity to appeal to the members to construct detailed linguistic maps of India. Almost similar is the question of racial affinities, but the results could not be mapped so easily.

3. MR. NAFIS AHMAD, Calcutta.

The scheme of the physiographic divisions of India as suggested by Mr. Pithawalla seems far from satisfactory. Firstly, a division of India on merely physiographic basis seems to lead the geographer towards a multiplicity of subdivisions largely based upon structure, and secondly, such potent influences as climatic, human, and cultural occupy a minor place in determining the geographical values of areas.

Dr. K. S. Ahmed's scheme as discussed by him is definitely an improvement on Mr. Pithawalla's attempt, but as he himself confessed it falls short of meeting a geographer's demand for describing the essential geographical potential of regions.

Mr. Kuriyan suggested to stick to a scheme of natural regions. And in addition made a plea for further fragmentation on linguistic and racial basis. Such a suggestion, to my mind, makes confusion worse confounded. The development of India in future will conform, and must, to a pattern of unity rather than isolation. The natural resources of areas according to their worth based upon structure, physiography, climate and human values will play their part towards common progress. If at all, a scheme of geographical regions sounds better. Why choose unhappy terms which lead to unnecessary controversy ?

4. MR. K. KULARATNAM, Ceylon.

After the learned criticisms and remarks I have heard to-day of Prof. Pithawalla's pioneer attempt at a division of India into Physiographic Divisions, I feel that Dr. Pithawalla should be congratulated for attempting a very difficult task, particularly as he has to deal with a region of continental dimensions like India, with a complexity and variety of geographic factors. However much we may differ from Dr. Pithawalla, our difference I should think is only with regard to details, and in this we may well agree to disagree. I incline to his fundamental basis of division, viz. a division based on geomorphological considerations. Physiographic

Division has in the ultimate to rest on geomorphology, for the physiography of a region is the result of the mutual interaction of geological history, composition, structure and climate. But it is unfortunate that after starting from this scientific standpoint he has shown a tendency to deviate from it in his further subdivision of the Major Divisions into Provinces and Sections, as when he introduces questions of soil fertility and crop variety as criteria. However, I feel confident that Prof. Pithawalla will deem it fit to revise his scheme in the light of these criticisms and give to geographers a much-needed division of India into Physiographic Units. I shall conclude by thanking Prof. Pithawalla for initiating this valuable discussion.

XII. ENVIRONMENT AND DISTRIBUTION OF POPULATION IN INDIA.

(*Section of Geography and Geodesy.*)

DR. S. M. TAHIR RIZVI, Aligarh, presided.

1. MR. GEORGE KURIYAN, Madras.

Dr. Ahmed has given us some basic facts linking population with environment. However, he seems to think that the seasonal rhythm and the religious sanction could in themselves account for the high density of population in India. But equally well it should be borne in mind that India has been peopled from very ancient times. Parts of the earth where settled populations have lived from times immemorial, generally have a tendency to show a high density of population, e.g. China and India. The low density of population in the U.S.A. cannot be accounted for by its poverty in resources, but is due to its recent history.

I do not agree with Dr. Ahmed when he says that a larger density of population will be found when there is a change in environment. Many examples to the contrary can be cited.

Dr. Ahmed again suggested that the ubiquity of water supply explains the high density of population in Bengal. In parts of Bengal, the real problem is the superabundance of water and the lower density in such regions are mainly as a consequence of it. It is not merely the ubiquity of the water supply that is important, more so is the type of food. Wheat and rice are the two staple cereals of India, and rice can always support a higher density of population per unit area. It is probably the rice culture coupled with the wealth of fish which definitely account for the higher density in Bengal. Dr. Ahmed again states that the density of population bears an inverse ratio to the thickness of vegetation. Obviously this is an overstatement, because as otherwise, the arid deserts should have the highest density of population. Within certain well-defined types of vegetation, the law laid down may be true, but I feel the exceptions are so numerous that it is better not to enunciate the main proposition.

It has also been suggested by Dr. Ahmed that excessive division of property has resulted in a nucleated village. To my mind, this process is not easily comprehensible. Nucleated villages arise from diverse reasons, e.g. the need for protection; the settlements around a temple, mosque or church, the settlements around an irrigation tank, etc. I therefore suggest that even if there was primogeniture, nucleation might still be found!

2. MR. B. VARADARAJA IYENGAR, Bangalore.

The population in parts of India is dense because India is peopled from ancient times.

The density of population in the rice-growing countries is very high because rice cultivation requires constant attention and a large number of field labour; whereas for wheat cultivation the attention need not be so regular nor the number of labourers required is so great. Hence, it is not merely the food value of rice that contributes to the higher density but also its cultivation.

XIII. THE CURRICULA FOR B.Sc. (HONS.) EXAMINATION IN THE VARIOUS INDIAN UNIVERSITIES; THEIR ADEQUACY OR OTHERWISE FOR FITTING GRADUATES TO UNDERTAKE RESEARCH WORK.

(Section of Botany.)

DR. S. RANJAN, Allahabad, presided.

1. MR. P. PARIJA, Cuttack, opened the discussion.

Some Defects in the Honours Curricula in the Indian Universities.

In opening the discussion the speaker said that there is a variety of curricula in the Indian universities, resulting in varying standards. In most universities the student has to study three subjects, two of which are subsidiary. The Boards of Studies in the subsidiary as well as the Honours subjects go on adding to the syllabuses in these subjects with the advancement of sciences. These additions make the courses very heavy for the students.

Another defect is that in some universities the three-year Honours Course runs side by side with Pass Course. The Pass student gets his degree in two years while the Honours student has to wait three years before he gets his degree. As graduation is a basic qualification for most employments, students prefer Pass to Honours Course.

These defects can be remedied firstly, by adopting the Honours School system of the Panjab University inasmuch as making all candidates for the M.Sc. to go through the Honours School. Secondly, the Honours student should study only two subjects, namely, the Honours subject as the main one and another allied subject as the subsidiary subject.

If the teachers assembled come to a measure of agreement, a suggestion may be made to the universities for recasting their curricula.

2. PROF. Y. BHARADWAJA, Benares.

There are two things which have struck me, and I think they should be decided first. Firstly, the standard of qualifications of a student for joining the Intermediate Course and, secondly, the standard of efficiency that a student is required to possess after passing the M.Sc. Examination. If we can settle these two points, we shall be able to make proper adjustment of the Courses of Studies for the various examinations. In some universities there is a two-year B.Sc. Course and a two-year M.Sc. Course in which there may or may not be a provision for research work in lieu of or bearing marks equivalent to those of a written paper. In other

universities there is. besides a B.Sc. Pass Course of two years' duration, a B.Sc. Honours Course of three years' duration. A student who passes such a B.Sc. Honours Course has to put in research work for one year only for getting the M.Sc. degree. Thus, in one case we have no or very little research work at the M.Sc. stage while in the other the M.Sc. degree is wholly by research. We have therefore to decide whether it is advisable to have compulsory research work during the M.Sc. Course or to allow research work only after the M.Sc. stage. This will naturally depend upon the standard of B.Sc. Pass and B.Sc. Honours Courses.

I have a feeling that early specialization is a very dangerous practice, and on the basis of my teaching experience of more than two decades, I dare say that in most cases the students after passing their B.Sc. Examination are not in a position to select a subject for research by themselves, as they do not know which of the subjects would suit them well. Under these circumstances they go by the advice of the teacher under whose direct influence they happen to come, and this often results in their taking up the subject of the teacher concerned. They have had absolutely no special training at the B.Sc. stage for the subject which they are obliged to take up for research for their M.Sc. degree. Whether it is B.Sc. Pass Course of two years' duration or B.Sc. Honours Course of three years' duration, our standard is certainly lower than that of the English universities, such as the London University, and unless Botany is started at the secondary education stage and brought up to much higher standards for the Matriculation and the Intermediate Examinations, it would not be possible to raise our B.Sc. standard and consequently advisable to have the M.Sc. Examination by research only, for research work should be taken up only after a student has achieved a considerable proficiency in the various branches of Botany and is able to find out for himself which of the subjects suits him best. No doubt, there is a great craze for research nowadays, and several young teachers amongst us are actually exploiting, so to say, the young students by putting them to research work at a stage when they neither possess sufficient proficiency in the theoretical and practical knowledge of the various aspects of the subject, nor the fundamentals of the technique of research. What kind of general botanists or researchers would they ultimately turn out can very well be imagined. So, this question of compulsory research work has to be decided as to whether it should be taken up during the M.Sc. Course or after that in view of the existing curricula for the various examinations.

3. Mr. G. Ahmad, Lyallpur.

If our aim is to prepare students for higher research in Economic Botany, we must include Physical Chemistry, Organic Chemistry, Mathematics, Cytology, etc., as a part of preliminary training during the B.Sc. Courses along with higher Botany Courses. For this purpose, we should adapt American system, say University of California curriculum necessary for the eligibility to work for M.Sc. or Ph.D. degree should be taken as our ideal. I am sure, by following this system, we will give better training to our future research workers in India.

4. Dr. F. R. Bharucha, Bombay.

In standardizing the curricula in Botany of different universities two points must be borne in mind:

(1) That we should diminish the morphological, anatomical, embryological and such old parts of the subject and introduce in greater and greater measure the more recent subjects like Physiology, Genetics, Ecology, Biometry, etc.

(2) We should make M.Sc. *compulsory by examination.* The first research degree should be the Ph.D. If this is followed

then the students will get two years of training in the methods of research and expand their store of knowledge by study on other correlated subjects. At present the research student for M.Sc. gets no time to read anything beyond on his own tiny problem of research and consequently is a very poor product.

5. DR. BAWA K. SINGH, Patna.

I suggest that the following points should be considered:—

(1) The time or duration of course for the Pass and the Honours B.Sc. Examinations.

I should suggest the period should be the same.

(2) *Research.*—Whether research should be allowed at the M.Sc. stage or at the post-M.Sc. stage is an important point in view of the recent advances made in sciences. The subject of research is intimately connected with the B.Sc. Course.

6. MR. V. S. RAO, Bombay.

The special paper should be omitted at the B.Sc. (Hons.) stage, and it should be made compulsory that the student learns the research technique employed in the various plant groups, and not merely in one. This is because the methods are widely different for various plant groups. Some other important items to be made compulsory are photomicrography, spectroscopy, and biochemical methods. The student should be capable of handling any research problem by himself, at least as regards the methods.

XIV. WORK OF THE BOTANICAL SURVEY OF INDIA: WHAT BOTANICAL SECTION OF THE INDIAN SCIENCE CONGRESS COULD DO TO ADVANCE IT.

(*Section of Botany.*)

PROF. B. SAHNI, Lucknow, presided.

PROF. S. P. AGHARKAR, Calcutta, opened the discussion.

Prof. Agharkar dealt with the subject from the following points of view:—

(1) How did Botanical Survey originate?
(2) How is it working?
(3) What is the work it has done and is doing?
(4) What should be its work in future?

1. PROF. Y. BHARADWAJA, Benares.

It is a fact that the scope of the work of the Botanical Survey of India has not been extended to that extent to which our Sub-Continent requires. It is very poorly staffed. There is only one officer in the Indian List, and he is in charge of the Industrial Section. Besides the Curator of the Herbarium and a Systematic Assistant, there is no other member on the botanical staff of this Department. This is really very disappointing. There should be a number of persons on the staff of the

Botanical Survey, and these persons should be set apart for different sections of Botany, such as Algae, Fungi, Liverworts, Mosses, Ferns, and so on. In the past attention has only been paid to the Angiosperms, and practically nothing has been done with regard to the identification and study of the Cryptogams. Without the Cryptogams no herbarium can be considered to be complete or representative of the plants of a country. During my European travels I found that in all State Gardens and Herbaria there were experts in various branches of Botany. Even for the Herbarium of the Royal Botanic Gardens at Kew there is an algologist to study the algae, and also experts in various other branches of the subject. There is thus an urgent necessity of increasing the staff of the Botanical Survey of India.

There should also be co-operation between the Botanical Survey of India and the Universities. We have now several Botany teachers in the Universities who are not only properly trained to do identification work but are experts in their own lines, and if the Government of India could grant some money to the Universities for the study of local floras, much work can be done in the way of making the Sibpur Herbarium representative of the various types of plants of the different provinces.

I would also support the establishment of an Advisory Committee for the Botanical Survey of India to advise this Department in regard to its working. This Committee should consist of representatives from the Botanical Survey of India, the Indian Science Congress, the Indian Botanical Society and the Universities doing post-graduate work in Botany. The Advisory Committee should again be split up into several Sub-Committees, consisting of 3 to 5 persons, pertaining to the various Sections of Botany, such as Algae, Fungi, Liverworts, Mosses, Pteridophytes, Gymnosperms and Angiosperms.

The Government should realize the necessity of expanding the Botanical Survey of India without any further delay, for it is only by proper identification and study of all kinds of plants that we shall be able to explore the possibilities of utilizing the resources of the country for its welfare, both economic and industrial. A census of all types of plants in the various provinces is urgently needed for the revision of the existing Provincial Floras and also for writing floras of unexplored regions.

The Government of India should be approached with a request to do the needful in the matter soon, as it affects the future welfare and prosperity of our country.

2. Prof. B. C. Kundu, Calcutta.

The speaker fully agreed with what Prof. Agharkar has said in connection with the formation of an Advisory Body to help in the work of the Botanical Survey of India. In this connection the speaker added that there should be arrangement for the lending out of specimens, including types, etc., if that is not possible, duplicates, to all bona fide Indian workers, so that they could work out these things and publish their results independently; thus, in this way local flora can be worked out.

3. Prof. S. Sampath, Benares.

It is suggested that—

(1) The universities be given a subvention and encouraged to keep herbaria of local floras.

(2) That adequate collections of Indian flora be available in at least three centres in India.

(3) In the central collection flora of countries adjacent to India be represented adequately.

(4) That the type specimens be not lent out, but only the duplicates.

The Chairman summed up the remarks of the various speakers and finally requested Prof. S. P. Agharkar to wind up the discussion and make practical proposals.

Prof. S. P. Agharkar then winding up the discussion moved the following resolution, which was unanimously passed :—

'Resolved that a Committee consisting of Prof. S. P. Agharkar, Prof. B. Sahni and Prof. P. Parija, with Prof. Agharkar as Convener be appointed to represent to the Government of India the necessity of the creation of an Advisory Board including representatives of the Botanical Survey, the Indian Universities, the Indian Science Congress and the Indian Botanical Society in connection with the Botanical Survey of India.

The functions of this Board should include determination of the general policy of the Botanical Survey and the allocation of funds for exploration purposes.'

XV. NITROGEN FIXATION IN THE SOIL.

(*Sections of Botany, Agriculture and Chemistry.*)

DR. N. R. DHAR, Allahabad, presided.

RAO BAHADUR B. VISWANATH, New Delhi, opened the discussion.

1. DR. SHRI RANJAN, Allahabad.

The discussion on the nitrogen fixation in soils may be divided up into three parts as follows:—

(1) The rôle of the leguminous plants.
(2) The rôle of non-leguminous plants.
(3) The rôle of light.

In this discussion the rôle of light or the photochemical fixation of Nitrogen in soils will only be dealt. Allen in Hawaii, Sarkaria and Fazaluddin in the Punjab, Carbet in England and Dhar at Allahabad have shown that photochemical action plays an important part in the nitrification of soils. According to Dhar the soil acts as a catalytic agent. Many mineral substances like titania, zinc oxide, alumina, etc., have been found to act as a photocatalyst.

Bhattacharya and Ranjan have shown that when molasses are added to soils the total nitrogen content increases. Thus they confirm the results of Dhar to some extent. They have also shown that the unsterilized molassed soils show greater value for total nitrogen over the sterilized ones, with the same amount of molasses, when exposed to sunlight. But when the molassed soils are sterilized, no change in the total nitrogen is noticed for the first 15 days, when exposed to light. Thereafter, for 15 days there is a rise and then the total nitrogen again becomes constant. Ranjan and Basu in an unpublished paper have deduced that the rise of total nitrogen and amino-acid nitrogen in the day may be due to the formation of the amino-acids from the energy derived by the oxidation of glucose. This rise of total nitrogen they were able to get even in darkness by injecting glucose solution in the leaf. After the injection glucose enters the leaf cells and causes an increased respiration. The energy thus released is utilized in the endoenergetic reaction of the synthesis of proteins.

These results can be usefully applied in the interpretation of the results dealing with the nitrification in soils. Both farmyard manure and molasses contain a considerable quantity of carbohydrates. So when these substances are added to the soils, oxidation of the carbohydrates

takes place. The agencies responsible for this oxidation are the soil micro-organisms on the one hand and light on the other. It is obvious that unsterilized soils do contain plenty of micro-organisms which oxidize the carbohydrates. In-vitro experiments by Dhar and in-vivo by Ranjan have shown that oxidation and respiration respectively increase in light. Thus one may conclude that by the photo-oxidation of the carbohydrates present in the soils, energy is set free, which then is utilized in the fixation of atmospheric nitrogen. Probably the soil structure also plays an important part in such a synthesis, for in the first step of the reaction probably the soil colloids adsorb the atmospheric nitrogen. The nitrogen thus adsorbed round the soil particle, then reacts by the help of the energy released in photo-oxidation of the glucose, to form compounds of a higher energy content.

2. Dr. N. R. Dhar, Allahabad.

Experiments carried on at Allahabad show that energy materials like carbohydrates, celluloses, oils, fats, etc., when added to the soil are responsible for fixation of nitrogen. The fixation of nitrogen in light is more than double that in the dark although the number of Azotobacters in light is much less than in the dark. There is also considerable N fixation even under completely sterile conditions and those energy materials are mixed with sterile soils or surfaces like Oxides of Iron, Zn, Mn, Silica, etc. In sterile conditions also there is more N fixation in light than in the dark.

Like electrical energy chemical energy may be used in N fixation. The energy of oxidation of carbohydrates, fats, etc. is very much greater than the energy necessary for nitrogen fixation, and that is why N fixation takes place in the dark. But when light, either natural or artificial, is applied and the soil renewed by cultivation, the light is absorbed and this absorption of light leads to increased N fixation.

From careful experiments it has been concluded that N fixation can take place under completely sterile conditions when an energy material is allowed to oxidize in a surface and the weight of N fixation under sterile conditions is the same as under unsterile conditions with the same energy material.

It is computed that 35 billion kilograms (seers) of cellulosic materials like leaves, hay, plant residues, etc. are added to the soil every year. On a moderate estimate of 10 mgm. of nitrogen fixation per gm. of carbon oxidized, about 13,000,000 tons of nitrogen are added every year to the earth.

3. Mr. U. N. Mahida, Bombay.

4. Mr. Rama Nagina Singh, Benares.

Biological agencies regarding the question of nitrogen fixation should not be ignored though the physico-chemical and chemical aspects are drawing greater attention. The rôle of blue-green algae in nitrogen fixation should not be lost sight of when dealing with the problem. Out of the results of the experiments carried out by the author it has been concluded that greatest amount of nitrogen is fixed by *Aulosira fertilissima* Ghose, growing commonly in paddy-field soils of Northern India.

XVI. POSITION OF SYSTEMATICS IN APPLIED ZOOLOGY AND ENTOMOLOGY.

(*Section of Entomology and Zoology.*)

MR. D. MUKERJI, Calcutta, presided.

1. DR. T. V. RAMAKRISHNA AYYAR, Coimbatore, opened the discussion.

Systematics in relation to Agricultural Zoology.

Biological studies on all organisms, whether plant or animal, are generally considered under three convenient categories: (*a*) General or Pure studies under which are included Morphological, Physiological, Embryological and Ecological features; (*b*) Economic, including the studies of the different characters of organisms which bear some relation to the material needs of man and the methods of utilizing our knowledge of such characters in that direction; (*c*) Taxonomic or Systematic studies comprising the correct recognition of all organisms without mistaking one for the other, their proper baptism according to the structural peculiarities they possess and their scientific classification into recognizable groups and sub-groups according to some generally accepted standards—such as phyla, classes, orders, families, genera and species. Under ordinary circumstances every worker on any animal or plant has to be conversant with the fundamental facts connected with all these three aspects to get complete and clear ideas of the organism he is studying; and this was more or less the nature of the work done by early naturalists who were morphologists, physiologists, taxonomists and even economic zoologists combined. But as years passed on, workers increased and our knowledge of the different aspects of organisms increased so much that it became impossible for one individual to carry on all these studies comprehensively; and naturally workers began to specialize in particular branches of biological studies. Thus we have to-day experts who have made intensive studies in each of these aspects of biology and who have become authorities on their chosen branches of biological studies. But unfortunately nowadays, as specialization and research in special problems rapidly advance, while we have a good many men who realize the great need for co-operation among workers on different branches of the subject of biology, we occasionally come across narrow minded individuals exhibiting superiority complex and who have, not only no regard for any other subject than their own, but even belittle the value of the many allied branches of study! In the words of Riley 'such a scientist who tries to build a wall against what he regards as rival subjects will only succeed in ensuring himself against recognition of himself by others'. It is gratifying to note, however, that all this snobbery and mutual bickerings are gradually disappearing. Speaking of the inter-relations of these aspects I may be excused if I repeat what I said in my presidential address to the Agricultural Section at Lahore two years ago, with special reference to Economic Entomology and Systematics. While I yield to none in my sincere appreciation of the great importance of the work of the economic entomologist or in my disapproval of the cheap sneer of calling Applied Entomology a 'mere bundle of methods', as one of my old bosses used to do with all the affection of a step-mother, I may be allowed to point out that there is a deplorable tendency in some quarters to belittle the value of work in the general or systematic aspects of Entomology on the score that such work may not be of immediate economic importance; such an attitude on the part of one who professes to be a scientist cannot be sufficiently deprecated; but unfortunately this spirit is prevalent even among some

of the present-day experts in different institutions. I might state without fear of contradiction that no entomological work of an applied nature can progress on correct lines without the sure foundation of sufficient studies on the general and systematic aspects of the science. I would invite the attention of such short-sighted persons to the opinions of some eminent zoologists. 'It is the systematist,' says Prof. Pearl of Johns Hopkins University, 'who has furnished the bricks with which the whole structure of biological knowledge has been reared; without his labours the facts of organic evolution could scarcely have been perceived, and it is he who to-day really sets the basic problems for the geneticist and the student of experimental evolution.' And in the words of Gahan, 'without the fundamental work of the taxonomist, the great mine of entomological literature would not exist and the accumulation of knowledge would be largely limited to what one could only personally observe and remember'. The first real economic entomologists were predominantly morphological and systematic entomologists, and without a thorough knowledge of the relations, habits, and method of identification of each insect we have to deal with, it will be not only difficult to proceed, but the task might be found risky and affecting the reputation of the applied entomologists. I would therefore invite the attention of future workers in Economic Entomology in India to bear in mind the well-known fact that systematic studies are the fundamental basis of practically all Applied Biology. Discrimination between species is the starting point of the majority of our biological problems, and ignorance of and indifference to this fact has invalidated many items of biological work in the past. I would invite the attention of workers who have still any doubts as to the excellent summary on this subject by Prof. Ferris:'Taxonomy or Systematic Biology is a serious attempt to discover, to describe and to arrange the facts of nature that have to do with the number, the characters and the relationships of all those indefinable groups of individuals that we speak of as *species* and to present these facts in as clear, as definite and as understandable a manner as may be in order that they may become available to all students of biology in whatever field they may be engaged. It of necessity involves the study of *morphology* and *anatomy*. It may utilize the methods of the *geneticist*. It may call often upon the physiologist and even in extremity upon the chemist for aid in solving its problems. As thus defined it undoubtedly involves far more than many systematists will be prepared to admit. As an independent field of investigation it can throw much light on the question of what happens to species after they have once become established. The whole great series of problems involved in the question of geographical distribution with the attendant conclusions and speculations as to places of origin and roads of dispersal of species and larger groups is approachable only by the systematist. Palaeontology is but little more than pure systematic biology, and whatever its contributions to scientific theory may be, they are the contributions primarily of systematists. The ever-fascinating problems connected with the study of ancient man and of human origins are essentially nothing more than problems in systematic mammalogy. Whether the "Piltdown man" was a man or merely a chimpanzee, the place of Java man in evolutionary theory, these are nothing more than problems of the systematist working as a physical anthropologist. Aside from these independent contributions to biological theory, systematic studies are the fundamental basis of *practically all applied biology* and of a large part of the remainder.'

A few words on the position of systematic work done in India, confining myself to Entomology may not be out of place here. Early work on Insects in India was mostly and necessarily of a systematic nature as may be seen from the numerous papers of pioneer workers like Westwood, Woodmason, De Nieeville, Bingham, Cameron, Hampson and a host of others and applied Entomologists of to-day owe a great deal to these early systematists for laying the real foundations for all

aspects of Entomological work in India. Even in spite of such help early workers in Economic Entomology like Lefroy and Fletcher had to carry on their work with some insects without knowing their identity and by calling them by numbers like convicts, policemen or railway trains! The Fauna of India series on Indian animals has rendered yeoman service to economic zoologists in India and it is gratifying to note that we have now over 40 volumes of this series dealing with insects; but it is needless to add that this has only touched the fringe of the very rich insect fauna of this large country. One important thing I would like to emphasize in this connection is that for the identifications of our insects we have been depending on experts in Europe and America for the past many years and it is deplorable that we have not as yet produced sufficient number of specialists who could help in identifying our insects properly and readily without the abnormal delay always experienced in getting our insect specimens identified from abroad—not to speak of the occasional losses of our parcels containing rare insects! In the Fauna series on insects, we have but one or two examples of Indians who are authors of these volumes on Indian insects. It is a pity! It is therefore highly necessary that we should have more workers on different groups who can help economic zoologists to get their organisms properly identified. In my opinion in the field of Systematic Entomology there is particular need for specialists in such groups as Hymenoptera, Diptera, Coleoptera, etc., which include several insects which render help to man as beneficial insects.

2. Dr. M. A. H. Qadri, Aligarh.

The position of systematics in the study of animals is determined by the rôle that systematic Zoology plays in animal studies. Apart from the correct identification of the animal which distinguishes it from the other it gives us a correct lead to the study of its morphology and physiology and finally to its relationship which is of paramount importance in determining its behaviour and ecology. The systematics is, therefore, a first step in the study of any animal problem pure or applied.

3. Dr. P. Sen, Calcutta.

The systematic works are no longer looked upon as dealing with purely philosophical aspects of Biology. Although the main concern of a systematist is to determine and classify species, our progress on applied biology practically depends on the contributions based on systematics. Without the proper nomenclature and means of identifying, it is impossible to correlate our knowledge on a particular species.

In Economic Entomology, the position of systematics is very high, for unless we can name correctly an insect which is found to be of economic importance and be able to distinguish it from allied forms, no quarantine or control measures can be adopted against it. In order to effectively control an insect pest we must know its taxonomy and know exactly what we have to deal with. The measures suitable for one species may not be applicable in the case of another, however closely related they may be. For instance, we know that only a few amongst the various species of mosquitoes present in a country are carrier of diseases, and unless we know how to distinguish these few mosquitoes and know against which the control measures have to be directed we would be wasting energy and huge finance in controlling every conceivable species.

The biological control of insect pests also depends to a great extent on the work of the systematists as this means utilization of certain parasites or predators against the pests concerned. On the proper identification of the parasites the whole structure of biological method of pest control is based. It is therefore clearly evident that for a successful tackling of an

insect problem the biological knowledge of the two groups of workers, the systematists and the economic entomologists must be co-ordinated.

4. Dr. K. B. Lal, New Delhi.

Systematic entomology arose originally as a matter of human convenience; later, it developed the elucidation of the relationship and ancestry of the animal forms as its motif, and lastly, it has now become important in connection with work on animals of economic importance. But perhaps in no group of the animal kingdom has systematic study assumed such great significance in relation to applied work as in entomology. The increasing attention now being paid to the study of insect pests and to the methods of combating them makes their correct identification the first essential preliminary of work. Many insects are now being shown to be different in their habits and life-history though identical in their morphology and it is obviously important to distinguish these forms, one of which may be very injurious and the other quite harmless. The study of the relationship of parasites to their hosts has brought out the necessity of accurate determinations of the identity of both, in order that the value or potentialities of any parasite in a given area may be correctly assessed. Recent ecological studies on insects have shown that many species assume different forms under different environmental conditions and if confusion in nomenclature is to be avoided and the economic entomologist is to hold fast to his work on any useful or injurious species, systematic work must limit the range of categories (genera, species, etc.) and define their stable characteristics clearly.

Much valuable information on a pest may be thrown in doubt by its incorrect, vague or insufficient identification. Such, for instance, has been the case with the cotton jassid, *Empoasca devastans* Distant in India. Early information on this insect, in all probability, is given under 'leaf hoppers', '*E. gossypii*', '*Empoasca* sp.', etc. In Britain, two well-known pests of apple, *Hyponomeuta padella* Linn. and *Psylla mali* Schmbg., have been discovered to have morphologically identical forms on hawthorn but the habits of the latter are so different from those that live on apple that their presence has been considered to constitute no danger to the apple orchards (Thorpe 1930, Lal 1934). The knowledge of this fact should save the apple growers all the efforts and expense of controlling 'these pests' on hawthorn. The well-known parasite of the spotted boll-worms of cotton in India, *Microbracon lefroyi* D. and S., and of the predators of the lac insect, *M. greeni* Ashm., have now been shown to be identical in morphology and, therefore, conspecific, but in view of their habits, forming two biological races. This fact has opened interesting possibilities in the exchange of hosts in the breeding of these parasites for purposes of control. The Braconid, *Microbracon hebetor* Say, has been recently reported to be full of possibilities for the control of the predators of the lac insect and it has become important to collect information about its biology and hosts. There is a strong suspicion that much of this information is given under *M. brevicornis* Wesmael, a very closely allied species, in fact so closely allied that it has been considered by many as synonymous with *hebetor*. The correct identity of these two parasites should, therefore, throw much interesting light on their biology and host relationships. Perhaps the most outstanding example of this kind is that of the locusts whose different phases were known as so many species till Uvarov's theory of phases in locusts became established.

A word has to be added about the scope and nature of systematic entomology itself. Although all taxonomic groupings have to be done on the basis of adult morphological characters which are more or less stable, considerations of biology, hosts, habits and habitats, not only of the adults but also of the immature stages, must play a part in confirming or correcting doubtful evidence of morphology. Without this consideration,

systematic entomology must remain divorced from all contact with and all understanding of the living insect. This view recognises that a competent systematist should also be a field worker and his work is best done in proximity to the environments where his insects live and breed.

5. DR. C. F. C. BEESON, Dehra Dun.

Dr. Beeson drew attention to the facilities for systematic work in Zoology and Entomology in India and asked that full use should be made of these resources in routine identifications and monographing of new material by more extensive co-operation between workers.

6. J. C. M. GARDNER, Dehra Dun.

It is not advisable entirely to abolish the practice of taking full advantage of the assistance of foreign specialists by sending them specimens for identification. What should be aimed at is the building up of authoritatively named collections in India. As progress is made dependence on foreign specialists will correspondingly decrease. At present a great weakness is the poor quality (by modern standards) of much past work and the absolute necessity of comparison with Types by competent workers.

The importance of determination of immature stages is emphasized.

An important point, if Indian students are to be employed as systematists, is that the present weakness in Indian education, namely, in foreign languages should be rectified.

7. DR. S. C. DATTA, Mukteswar (U.P.).

Importance of systematics in Veterinary Zoology.—The subject is so very large that the miniature zoological staff of the Vety. Dept. can do very little on systematics without the help of zoologists in better positions and of those provided with better facilities. Drug specificity shown by very related species of protozoan parasites of India makes systematics of fundamental in disease control work. The parasitic fauna of animals is very large in India and animals live under relatively unprotected conditions. Systematics in Vety. Zoology is very important, and in my experience perhaps more important than systematics in other spheres of applied Zoology in the present state of India.

8. DR. B. K. DAS, Hyderabad-Deccan.

Systematic study is very important but *not the fundamental* aspect of any purely zoological or entomological work. Morphological work combined with environment and adaptations is the key-note of all biological work and in unveiling the secrets of life—systematic work is very mechanical and should be left in the hands of museum and Government Research Institutes experts. Young men should always be encouraged for systematic work.

XVII. RACIAL NOMENCLATURE.

(*Section of Anthropology.*)

MR T. C. DAS, Calcutta, presided.

1. DR. A. AIYAPPAN, Madras.

Opening Remarks.

The purpose of this discussion is to elicit how much of agreement there is among students of anthropology on the various race names suggested during recent years for the peoples of India. Though much remains yet to be known, we know more to-day about the physical characteristics of Indians than we did after the 1901 census, thanks chiefly to the work of Dr. Guha As a consequence of our new knowledge, race names suggested by Risley have most of them been given up by all except perhaps writers of school books. The difficulties of the average teacher and worker dealing with anthropology have been increased by the controversies raised on race problems by Prof. Eickstedt who has given parallel names for several groups. Controversy is to be welcomed as it is a sign of developing interest in the subject and of intellectual health. The problems are so complex and our population so large that finality is not to be expected of the few workers. We feel that it is, however, possible to sit together and discuss and come to provisional agreement on certain points, and assess the merits of the various suggestions now holding the field.

Some of our difficulties are due to the complications inherent in our material. We know so much more about human beings than an ornithologist, for example, knows about birds. When, as in the case of our species, variation is known to be very great classification becomes complex. Mixture has been the rule for humanoids even during the Sinanthropus epoch, and to gauge the consequences of such ancient intermixtures is baffling. Any race study is made possible as a consequence of geographical isolation and selection which intensifies the characters possessed by some groups here and there whom we regard as pure for our purpose. Such are our marginal tribes, the Andamanese, the Assamese and to a lesser degree the proto-Australoids. The rest of our population is a continuum, groups merging one into the other, the boundaries being very difficult to notice. The only races that can possibly be detected in such a mixed population are statistical races. An individual, family, group, caste, etc., may show a mosiac of characters. As a result however of endogamy and geographical and cultural barriers, characters show local concentration, and statistical studies give results which are not mere mathematical abstractions but approximate to biological races.

We have to bear in mind very clearly what we mean by races when our chief tool of investigation is statistics. No room should be left for politicians or the lay public to misunderstand what the anthropologist means by races. We also ought to remember that inheritance in human beings is complex due to the multiple factors for most of what we term racial characters. Blending is far commoner than simple dominance or recessiveness. Caution is also demanded of us in another direction. After everything is said and done, there remains in every attempt at classification whether of plants or of animals, a certain amount of subjectivity. Species has been defined as 'a community or a number of related communities, whose distinctive morphological characters are in the opinion of a competent systematist, sufficiently definite to entitle it, or them to a specific name'. It is the experience of biologists, as a rule, that the expert in each branch informs his intuitive feelings with intelligence and gives

valid reasons that convince his fellow workers. And those experts called to the work of classification have in their turn to bear in mind that 'a name once published is irrevocable, a permanent addition to the labour of future investigators. Let us beware of adding needlessly to the burden of posterity'. When, as in the case of mankind, classification has not only scientific but immense social consequences, I hope no one will enter on this field without the full recognition of his responsibilities.

Consistent with what has been said above I shall attempt only to clarify certain issues, as under existing circumstances it may not be possible for us to come to definite conclusions.

Two distinguished experts have recently surveyed the scientific position of raciology with reference to India. The latest attempt by Prof. Eickstedt takes the form of a lengthy introduction to 'Travancore Tribes and Castes', Vol. II. The other is by Dr. Guha in 'An Outline of Field Sciences in India'. Though superficially different, the general outline of the position given in these two papers shows a substantial degree of agreement. The tangle seems to be chiefly terminological.

The Negritos.—The existence of the Negrito race in India is based on the discovery in Cochin State, Assam, and Santal Parganas of individuals with frizzly hair, one at least of whom is also short-headed. It is difficult to understand why some anthropologists persist in denying the existence of frizzly hair among the Kadars, etc.

On absolutely theoretical grounds, Hrdlicka expected to find traces of a negro-like strain in the intermediate regions between Africa and the Andamans, and in the course of his tour of India in 1925 he was satisfied it did exist.

Whether the Negrito preceded or came after the Australoids is a moot question. Dr. Guha is inclined to the former view. On the assumption that frizzliness is a recessive character, he argues this character is being swamped out as a result of intermixture with wavy-haired elements. Woolly hair has been shown to be dominant in a Scandinavian case whose history was followed for five generations (Mohr in *Journal of Heredity*, *23*, 345–52, quoted by Gates). If among the Kadars also it is found to be dominant, frizzliness can only be explained as a passing trait. It may be that this trait is a recessive in the Kadars! If the Negrito were once widespread and the trait that distinguishes them were a dominant one we ought to expect a more general frizzliness in the geographical pockets in which we find it in the course of its discontinuous distribution. It might be suggested that the Negritos were there but as a passing influence on the jungle tribes.

The Tasmanians of the Australian region present a parallel problem to that of the Negritos in relation to the hill tribes of southern India. The Tasmanians had woolly hair and slightly broader heads than the Australians, but apart from these, every other feature was Australoid. With regard to them, Howell and Warner come to the conclusion that they are Australoids modified by Melanesian influence, and that the postulate of a Tasmanian strain spreading over the whole continent of Australia would be untenable.

Veddid and Proto-Australoid.—These terms have been used to describe the racial element that goes chiefly into the making of the hill tribes of central and southern India. About the distribution of this strain there is general agreement though Prof. Eickstedt excludes from it several of the tribes of central India. The older terms pre-Dravidian, Nishadic, etc., for this group have to be dropped in view of others that are more appropriate. The term Veddid (Eickstedt) is suggestive of the relationship that the hill tribes mentioned bear to the Veddahs, but there are some objections to its acceptance, the first of which being that the Veddahs are not quite representative of the bulk of the tribes sought to be named after them. Eickstedt himself regards them as very much mixed up with the Singhalese; and Hrdlicka regards them as not so very much primitive as they have been usually supposed. 'Proto-Australoid,' on the other

hand, has the advantage of being comprehensive as it includes the hill tribes of southern India and the Veddahs, and of showing up the evolutionary link between Australian and South Indian tribes.

Objection, however, is likely to be raised with regard to the prefix 'proto' which suggests that the South Indian tribes are more primitive in an evolutionary sense than the Australians. All our best authorities are agreed that the latter are the most primitive of all living races of mankind. The pronounced eye-brow ridges, prognathism and hairyness are all signs of extreme primitiveness, not specializations, when these are considered from the Hominid angle. The hill tribes of South India are more 'progressive' in these respects, while in such characters as stature they are primitive.

Another interesting fact to remember is that the Australoids of India (Indo-Australoids), like those of the island continent, are proto-Europids the archetype from which the races of Europe have evolved. Blood group studies have confirmed this belief.

Basic dolichcephalic type.—This exists mixed with the proto-Australoid strain on the one hand and the Mediterranean on the other. The Melanid group of Eickstedt seems to be the equivalent of this, but unfortunately the Melanid is more subjective than most other of this expert's races. The Melanids of Eickstedt are confined to southern and central India, the latter are being the home of the 'Kolid' branch of the Melanids. Eickstedt's Kolids however are proto-Australoids according to the other authority. Here then is the need for further clarification of the positions held. Eickstedt regards that the Melanids belong to a 'very old component of the Negrid main race'. He has not stated what is 'the influence of an old proto-Negritid component since long entirely sucked up' that he has discovered among the Melanids except it be melanin in their skin which by itself is not diagnostic of race.

Dr. Guha's name for the type has the advantage of being non-committal and provisional. Melanid, a wrong name suggested when very little work has been done, need not be revived.

Indid Race.—Eickstedt lumps together under this name several types with diverse skull forms. Extreme brachycephals and dolicocepahs are all grouped together. If this were to be done for Europe it would have only one race! His Indid proper are however easily recognizable as the Mediterranean of Guha, but he objects to the latter term on the ground that the race names of Europe are to be tabooed (p. xlii) from Indian race studies. Panchanan Mitra found it convenient to use European terminology in the prehistoric field, but no one now considers that he was wrong. Eickstedt's criticism of Mitra on this score is not justified. Eickstedt does not explain clearly what he means by North Indids, and until he does that we need not bother about it.

Regarding the rest of the terms suggested by Guha no differences of opinion have so far been expressed, which means that they are acceptable in the present state of our knowledge of Indian raciology.

2. Mr. H. C. Chakladar, Calcutta.

Risley gave seven names to peoples of seven areas of the Indian Empire, and in spite of the fact that most of them have been found to be either wrong or unsuited, they continue to be employed by even scientific writers about India. Risley's Dravidians include four distinct physical types. For one of these groups, the Sarassins used Veddaic, Thurston and Haddon Pre-Dravidian, Chanda Nishada, and Guha—Sewell—Hutton Proto-Australoid. Giuffrida-Ruggeri, Ghurye, Guha, and Eickstedt—each has his own classification of the Indian peoples, and necessarily a different nomenclature. Attempts have been made to introduce some of the names recommended by Deniker or Fischer. The result is that for many groups of Indian men there is a multiplicity of names, sufficient to puzzle the lay reader or writer. If we take into consideration the

racial types of the whole world, the variety of names that meet us grows simply bewildering, and besides, there are differences in the fundamental conception of race. The young science of Anthropology must wait yet a while, before any unity in nomenclature, as in the other Natural Sciences, can be expected. Anthropological workers interested in India, however, may meet and seek to devise at least a provisional set of names intended to connote definite groups of our men.

3. MR. J. K. BOSE, Calcutta.

A standard terminology of different groups in India for ethnological purposes is a necessity. The earlier ethnologists have used different names for the same ethnic group. But before accepting or rejecting any of these terminologies we have to consider on which basis the new terminology for the Indian people will be made. Also whether any relation with ethnic groups outside of India will be taken into account.

4. DR. P. C. BISWAS, Calcutta.

The present discussion reminds me of the discussion on the same topic that took place in the International Congress of Anthropological and Ethnological Sciences held in London in the year 1934. In that discussion Prof. Von Eickstedt, Dr. Guha, Mr. Codrington and Rai Bahadur Ramaprosad Chanda, Prof. K. P. Chattopadhyay and late Dr. Ananta Krishna Ayer took part. That discussion ended without any settlement.

This discussion of Racial Nomenclature at this stage is not possible as we have not got sufficient number of Somatological measurements of the people of our country by trained Anthropologists.

Risley's measurements though published all under his name were made by four persons without anthropological training and the other two Dr. Guha and Prof. Von Eickstedt measured very few people taking in consideration the population of India.

Thus it is necessary to measure sufficient number of Indian people, then we will be in a position to classify and propose name for those.

5. CAPT. R. N. BASU, Calcutta.

Anthropology—the study of man in groups—emerged, as you are all familiar, from a very crude stage and has built its structure on bed-rock of knowledge. It is a misfortune that every one assumes that he has a wide knowledge of the subject, and ignorance due to unscientific turn of mind does not deter such people from passing fanciful judgments, no matter how much controversial the subject is, on many scientific matters in Anthropology. Sometimes, such judgments are passed on some very intricate anthropological problems for political purposes and for influencing public affairs of the country, discrediting altogether the question of what people are but what these specialists think about the people. Scientific nomenclature of the people has become very much complex owing to racial intermixture.

The materials on the basis of which racial nomenclature of the peoples of India has so far been attempted are very scanty and from statistical point of view we will not be justified in accepting any theory based on such scanty materials. The distribution of physical characters in a small series will always be irregular and the peculiarities in such a series may also be due to chance selection and it will be rather wrong to accept any theory based on such peculiarities of the group.

Zoologists classify animals into genera and species and use nomenclature based on physical characters but for nomenclature of the different groups of mankind, the anthropologists have taken recourse to not only biological evidence but other evidence which are cultural in nature. For racial nomenclature biological nomenclature is all the

more important whereas cultural evidence is necessary for practical politics. Physical anthropology meets cultural anthropology only on historical grounds—one supplementing the other. Racial nomenclature of the peoples of India so far attempted was under the influence of the philologists and as such it is bound to create physico-anthropological contradictions. Nomenclature based on cultural evidence may denote what people do or their ancestors did but they are unable to delineate what types they belong to or what is their origin.

The first attempt at racial nomenclature of the peoples of India was undertaken by late Sir Herbert Risley,* a member of the Indian Civil Service. Risley classified peoples of India into seven ethnic types on linguistic, geographical and physical characters and I doubt very much if physical characters and language would meet to fulfil the purpose of racial nomenclature in India. He recognized three racial elements in India, e.g. Dravidian, Mongolian and Aryan—the Turk and the Iranian as found in the composition on the Turko-Iranian type cannot be taken as primary ethnic elements. Again, in the Dravidian group of peoples—a term linguistic in origin and coined by Risley—we find peoples of diverse physical types and any nomenclature based on language spoken is untenable unless supported by non-adaptive hereditary physical factors in the light of recent biological studies.

Next, racial nomenclature of the peoples of India was undertaken by G. Ruggeri on the evidence of the existing data at the time. According to him six racial elements have entered into the composition of the peoples of India:

(1) Negritoes.
(2) Pre-Dravidians (Australoid-Veddaic).
(3) Dravidians having affinity with H. Indo-africanus Aethiopicus.
(4) Tall Dolichocephalic elements—Mesopotamic ?
(5) Dolichocephalic Aryans—H. Indo-europeus dolichomorphus.
(6) Brechycephalic Leucoderms—H. Indo-europeus brachymorphus.

Prof. Eickstedt who came to India under the auspices of German-India expedition, carried out some anthropological investigations and on the basis of his studies of about 3,000 individuals, manufactured some fanciful names for the different groups of people in India and proclaimed before the world that he found a basic Negrid strain among some of the tribes of India. He says that his Melanids are the indidized descendants of the Eastern branch of the Negro race and the inference was drawn from the dark brown black skin colour. Again he says that the shape of the base of the nose, of the lips, the chin and the hair of the Melanid group are between Negrid and Europid groups whereas the face and the bodily proportions are essentially Europid. Prof. Eickstedt also did not hesitate to use linguistic term for his nomenclature though he found fault with Risley for the same.

Next, the turn of events brought Dr. J. H. Hutton, another member of the Indian Civil Service, to play a prominent part in the field of racial nomenclature of the peoples of India with the assistance of Dr. B. S. Guha of the Zoological Survey of India. Dr. Hutton was the Census Commissioner of India in 1931 and as an auxiliary part of his voluminous work conceived this idea and possibly with a purpose. According to Hutton, the following racial elements entered into the composition of the peoples of India.

(1) The Negrito.
(2) The Proto-Australoid.
(3) The early branch of the Mediterranean race.
(4) The second wave of Mediterraneans from the Persian Gulf region.
(5) The third wave of Mediterraneans.
(6) The Southern Mongoloids.
(7) The Indo-Aryans.

The confusion arises with the term Dravidian, and according to Sergi and Deniker there are two types among the Dravidians of Risley—long head, medium stature and messorrhine nose and long head, short stature and platyrrhine nose. The first of the two types was called Dravidian and the second as Pre-Dravidians by some of the anthropologists. Mr. R. P. Chanda (now Rai Bahadur) would call the second group as 'Nishad' denoting a number of tribes living in the hills and forests and of very dark colour, low statured, etc. Chanda bases his theory on physical measurements but unlike Risley attempts to separate the groups on the basis of nasal indices.

These Pre-Dravidians were later named as Australoid-Veddaic by Ruggeri, on the assumption that the Veddahs of Ceylon, the primitive tribes of South India and the Australians are of the same common origin. But Zuckerman in his Bulletin on the Adichanallur skulls makes it clear by quoting almost all the authorities, who have dealt with the South Indian Craniological material, that 'craniological evidence derived from the present population of Dekkan does not support the hypothesis of a pre-dravidian racial stock whose representatives are, amongst others, the Australians, the jungle tribes of South India and Veddahs of Ceylon'.

Dr. Hutton, on the other hand, tried to affiliate the primitive tribes of South India and the Veddahs of Ceylon with the Palestine man and through the latter with the Neanderthals of Western Europe. Hutton asserted that the Kish skull may be said to be the connecting link between the Palestine man and his Proto-Australoid types of India but it is rather strange that Dr. Hutton failed to explain the great differences in the nasal indices between the Kish skulls, Adichanallur skull, Veddaic skulls of Mohenjo-daro and his Proto-Australoid skulls of India. Colonel Sewell tried to associate the Indian Proto-Australoid type with the Australians on the one hand and the Rhodesian man on the other hand. Dr. Hutton, at the instance of Colonel Sewell, attempts to associate his Indian Proto-Australoid type with the Palestine man and the western Neanderthals. Osborn writes in his book 'Men of Old Stone Age' as follows:—'In brief, the Australian type of head has nothing in common with that of the Neanderthals except in a number of characteristics in the region of the forehead and of the nose'. Boule writes in his book 'Fossil Men' as follows:—'All these modern so-called Neanderthaloid are nothing but varieties of individuals of Homo sapiens, remarkable for the accidental exaggeration of certain anatomical traits which are normally developed in all specimens of Homo neanderthalensis. The simplest explanation of these accidents in most cases is atavism or reversion. We cannot assert that there has never been an infusion of Neanderthaloid blood in the groups belonging to the species Homo sapiens, but what seems to be quite certain is that any such infusion can have been only accidental, for there is no recent type which can be considered even as a modified direct descendant of the Neanderthals'. Moreover, the distribution of blood group among some of the South India tribes as carried out by Malone and Lahiri is quite different from those of the Australians.

The destiny of the Indian peoples for scientific nomenclature devolved, so long, upon persons whose object was mainly directed for the propagation before the world about the inferiority in origin of this subject nation for the purpose of maintaining their political domination.

The problem of racial nomenclature is a very intricate one and requires a careful study and a mass of data has to be collected for the different groups of peoples all over India. After discussing the various pros and cons a well-planned formula is to be thrashed out which will stand the vicissitudes of environment, nutrition and other factors otherwise any nomenclature of the peoples of India is futile to attempt.

XVIII. DETRIBALIZATION AND ACCULTURATION.

(Section of Anthropology.)

MR. T. C. DAS, Calcutta, presided.

1. MR. NIRMAL KUMAR BOSE, Calcutta.

Opening Remarks.

Three cases of recent cultural change are first cited. The Juangs of Orissa are not considered to be Hindus, but they have already begun to worship Hindu gods and goddesses. Some Mundas and Oraons of Ranchi put on the sacred thread for a number of days during the Manda festival, employ a Vaishnava priest and virtually live the life of a Hindu for a short period within the year. The Muchis of Bolpur in Western Bengal have recently been subjected to reform movement, under the influence of which they have been trying to give up certain 'unclean' customs and adopt a manner of life closer to that of the high and clean castes.

Thus several tribes and castes have been subjected to the dominance of Hindu culture in recent times. It is suggested that this domination first started in the economic sphere. When a tribe becomes economically subservient to another, it also becomes subservient to them in social as well as cultural matters.

Proofs of culture changes in early times are cited from the Mahabharata and the Manusamhita, and it is shown how, in those times also, economic domination was the most important operative factor. Tribes, who were absorbed, were converted into a caste and given monopoly in a particular occupation within a given area. In this way a productive system was built up through hereditary monopolistic guilds. As long as this productive system endured the caste system remained stable, and when the productive system broke down, caste was subjected to disruption.

In the Hindu method of acculturation, a policy of laissez faire was adopted with regard to the religious and social culture of the absorbed tribes. A machinery was set up for bringing them in line with Brahmanical morals, but no violence was done to those cultures. A pantheistic form of social idealism prevailed in those times.

A comparison has been made between the Russian plan of acculturation in Turkestan and Uzbegistan with that of the Brahmins with regard to the aboriginal tribes in India and certain distinctions have been drawn between the two.

With regard to the future, it is said that all attempts at acculturation should first begin with economic rehabilitation of a tribe. When that is achieved, the rest will follow with ease.

2. MR. M. N. BASU, Calcutta.

The author's personal experience with the life of the Bunas and the Noluas of Bengal in connection with culture contact may be cited. The Bunas are a class of people brought by the indigo planters or the big Zeminders of Bengal to employ in their firms or houses. They are now shunned by the two principal communities of Bengal, viz. the Hindus and the Muhammadans. In this paper the author wants to show how much of the Hindu or Muhammadan influence has entered into their culture composition. The Noluas of Bengal are a social group living in the four districts—Jessore, Khulna, Faridpur and Nadia. They are Muhammadans but they were originally Hindus. The author will show how the Hindu influence is gradually overpowered by the Muhammadans.

3. Mr. J. K. Bose, Calcutta.

Acculturation is in progress amongst the primitive tribes who have settled in Bengal. The Plains Garos of Mymensingh are one of such instances.

The material culture of the Plains Garos has undergone considerable modifications due to local influence and to adapt the life in this new environment. Social regulations have also been modified to a great extent for different reasons. The physical features have been affected by admixture with local people. In religious life a curious blending of some Hindu gods and goddesses with Garo deities has been made.

4. Dr. A. Aiyappan, Madras.

Diffusion by prestige has been the real process in the changes undergone by various tribal communities of India. It is doubtful if, at any time, there has been a conscious artificially organized mechanism for changing the culture of the tribes. There may have been attempts made by upper castes to exploit the lower castes and tribes, and these may have included efforts to change certain rites obnoxious according to Brahminical standards—whether Ancient Hindus ever attempted to Hinduize Indian tribes in the manner of modern missionaries to Christianize them—this is a very difficult problem.

5. Prof. K. P. Chattopadhyay, Calcutta.

The speaker pointed out the operation of the two ways of acculturation—(*a*) the Western European missionary method, and (*b*) the Eastern or Hindu method, among Santals. In the Daman-i-Koh, the Santals are carefully kept apart from the Hindus and other Indians. But the Christian missionaries have been given rent free grants of land to work in this area for the last seventy years and more. The result is that the Santals have lost a good deal of the beliefs round which their social life has been built up. A break up of the tribal life is inevitable in such circumstances even though the economic safeguards are effective. On the other hand, in Mayurbhanj, the Santals are classed as tribal Hindus and are encouraged to feel themselves one with the other members of society there. The result is that the older social traditions have survived but in contact with the higher culture, cruder expressions of belief have been checked. As anthropologists we have to decide which way of acculturation is better and stress it. The first method destroys the older traditions. But new traditions cannot be built up in a day. The second method turns the crude, urges into more refined channels, without causing a break in the traditions. India has a tribal population of twenty millions. We cannot afford to let them be detribalized and left to drift, culturally. We have to place our views before the public and persuade them to take up this task.

6. Brij Mohan Lal, Hyderabad-Deccan.

Gonds, Bhils, and Chinchus reside in Hyderabad State. Gonds and Bhils have come under the influence of higher civilizations in the present and a study of their culture and customs may throw light and explain some of the complicated customs of the Hindus. It is harmful to the tribes if their primary ethical beliefs are broken down, as it is unable to assimilate a higher ethical standard, having not risen the standard of civilization. Even the members of the tribe take up the deities of the absorbing civilization and adopt them to their own, e.g. Virgin Mary is worshipped by them in the spirit of a devi.

XIX. CORRELATIONAL ANALYSIS OF ANTHROPOMETRIC MATERIAL.

(Section of Anthropology, in co-operation with the Indian Statistical Conference.)

PROF. K. P. CHATTOPADHYAY, Calcutta, presided and opened the discussion.

In his opening remarks Prof. K. P. Chattopadhyay referred to the imperative need of using the sampling method in anthropological studies. But he uttered a warning against the danger of bias in the selection of samples, illustrating his argument with examples. A working knowledge of statistical methods, he declared, was essential for anthropologists, for without it they were liable to reach conclusions which would be more in agreement with their personal prejudices than with observed facts. He concluded by stressing the urgent need for standardization of measurements on the living.

2. PROF. D. D. KOSAMBI, Poona.

The speaker gave a most interesting summary of an ingenious application of statistical methods for studying the chronology of ancient Indian coins. He found that the old Indian coinage found at Taxila and other places showed remarkable homogeneity in weight distribution. The average weight of coins showed a close linear correlation with the number of punch-marks on the coins. On certain plausible hypotheses this provided a method for fixing the chronology of the coins.

3. MRS. CHAMELI BOSE, Calcutta.

She presented a paper dealing with the correlational analysis of anthropometric material relating to 13 Bengal castes and tribes originally published by Sir H. H. Risley and revised by Prof. P. C. Mahalanobis in 1933. On the whole the material was found to be of the multivariate normal type with linear correlations.

In the discussion which followed Prof. P. C. Mahalanobis stressed the importance of the standardization of measurements, and referred to the brilliant application of the statistical method made by Prof. Kosambi in studying the chronology of ancient coins.

Prof. Chattopadhyay brought the session to a close with a few remarks on Mrs. Bose's paper which he considered to be noteworthy.

XX. FOOD PLANNING.

(Sections of Medical and Veterinary Research, Physiology, Agriculture, Geology, Geography and Geodesy, and Engineering.)

MR. P. M. KHAREGHAT, New Delhi, presided.

1. MR. A. C. UKIL, Calcutta.

Opening remarks.

The following points are worthy of your attention in connection with food planning in India:

The net available stock of any agricultural commodity is made up of (1) production, and (2) import *minus* export and seed requirements. One should know whether the net cropped area in different provinces is sufficient to meet the food requirements of the population and to supply them with sufficient cash crops to permit the ryot to buy the other necessities of life with the economic return from their sale. If not, it should be considered whether a certain proportion of population can be absorbed into the industries, either part or whole-time, for obtaining the necessary economic solution of their basic needs.

It is now accepted that a vast majority of the population in many parts of India are on a subnutritional level, the result of which is reflected in their poorly developed, toneless and physically inefficient condition, with chronic ill-health and low resistance to diseases. The minimum cost of diet for an individual, at prevailing prices, has been estimated by Dr. Aykroyd at Rs.5 per mensem. This represents the average monthly income of an Indian, but against this background may be placed the following example from Bengal:—

There is an average of 5 persons per house or unit of family and there are 2·5 non-working dependants to every earner and worker. Each such family in Bengal has only 3¾ acres of cultivable land, as against 21 acres in England. The living expenses of such a family consist of (*a*) food, (*b*) other necessities of life, such as tobacco, light, utensils, fuel, clothing and repairs to dwelling houses, (*c*) medical expenses, (*d*) social functions, and (*e*) cattle food and manure. The cost of food at Rs.5 per head per month for a family comes to Rs.300 per annum. Other necessities of life based on the figures supplied by the Hon'ble Sir Azizul Huque (Huque—The Man Behind the Plough, 1939) cost Rs.40 per annum. Medical expenses have been put down to Rs.24 and social functions at Rs.6 per annum. To this may be added manure at Rs.15 and cattle food at Rs.25 per annum. The total comes to Rs.400 per annum. Besides these, the ryot has to meet the rent of land, cess, union rates, labour charges, bullock charges, cost of seeds, ploughs and other implements, interest on debt and perhaps some repayment of debt. Sir Azizul puts the amount of fixed liability of a peasant family for the above at Rs.125 per annum. The above two major items added together make Rs.525 per annum, which represents the fare minimum for a healthy living, without any provision being made, however, for education, recreation, and some measure of economic security. Against this, the present annual income of a peasant family is Rs.180 to Rs.250. This means that the Bengal peasant needs to raise his income three times if he has to lead a healthy life according to minimum standards. What holds good in the case of Bengal is probably also true for the greater part of this subcontinent. An adequate food production for such a population must need careful consideration from scientific workers and administrators alike.

It has been stated that the production of cereals in India has fallen short of the increase in population. Between 1900 and 1934, the area under food crops has increased by 9%, whereas the population has increased by 21%. Although the production of cash crops seems to have proceeded *pari passu* with the growth of population, the small economic return from it has not been able to meet the basic needs of the ryot regarding food, clothing, fuel, housing, social needs, farm equipment and payment of debt.

In spite of India's being a predominantly rice growing country, every year she has to import 12–14,00,000 tons of rice.

The proportion of sown to total area of land in different provinces varies between 16% in Sind to 58% in Delhi, the average being 34·2%. 22–40% of land represents cultivable waste other than fallow. The population per 100 acres of sown area varies between 60–297, according to the density of population. 81% of the land is employed in the production of food grains (76·3%), sugar (1·7%), condiments and spices

(0·5%), fruits and vegetables (1·8%) and miscellaneous food crops (0·7%), and 19% of it is employed in the production of non-food or cash crops, including fodder crops (4%). Agriculture cannot support more than 250 persons to the square mile, whereas in some provinces, e.g., Bengal, the average density of population is 650 per sq. mile. Our first duty, therefore, is to reclaim, with the aid of drainage, irrigation and enrichment of soil the large amount of cultivable waste land in the country.

It is well known that India grows less food crops per acre than most countries which have applied science to the service of man and animals. For example, Java and Siam grow 1⅓ times and Korea and Japan 3 times the quantity of rice from the same area of land as in India; as regards wheat, information reveals a similar position. In India only 6% of the area under total crops is at present under new and improved crops. The soil in most parts of India has now reached a stationary state of fertility at a low yield level as a result of cultivation over many centuries, without adequate retention of organic matter and phosphates and due to the lack of proper soil management in several important directions.

The causes of agricultural deterioration are usually absence of adequate irrigation facilities, silting up of rivers and irrigation tanks, bad drainage of waterlogged areas, floods and denudation of forests. The proportion of irrigated to total sown area varies between 7% in Bengal to 56% in the Punjab, the average for India being 13%.

It is generally known that there is food shortage in India not only quantitatively but also qualitatively. There is serious shortage of 'protective' foods in the dietary of the Indian, e.g., milk—the daily per capita consumption in India is only 7 oz., as compared to 39 oz. in Great Britain and 45 oz. in Australia. In Bengal, it is only 3 oz. per capita and on the top of it Rs.60 lakhs worth of milk products are annually imported into the province from foreign countries. Even where very useful research has been made in India and other countries with regard to the improvement in the quality and quantity of crops, its application has generally lagged behind in India.

India has gradually become, during the post-war period, a food importing country and her internal food supply has fallen short of her requirements. Each family in Bengal has only 3¾ acres of cultivable land, as against 21 acres in England.

The gradual expansion of cultivated area and the almost complete conversion of pastures into tilled lands in many parts of India have resulted in the impoverishment of cattle. In Bengal, for example, there are 30–69 animals to the acre of grazing land, whereas it is estimated that ½ acre is needed per animal. Dr. K. C. Sen stated yesterday that there was 45% food shortage among cattle in India. The number of cattle per 100 acres sown in Bengal is 108, as against 67 for the whole of India, 15 of China, 25 of Egypt and 6 of Japan.

It is not possible to develop grazing areas without combining the dairy industry with farming and without eliminating useless breeds of cattle and introducing better breeds instead.

A crop planning conference was held, under the auspices of the Imperial Council of Agricultural Research in 1934, but it failed to indicate how to correct the lag. A judicious crop planning implies the introduction of improved and purer varieties of crop seeds and of improved methods of cultivation with the aid of more efficient implements and proper manuring; the application of a suitable cropping scheme by judicious distribution of grain, fodder, money crops and a soil-recuperating crop on the available soil, a better control of pests and diseases to avoid the loss in yield caused by them; demonstration and education of farmers with regard to the equitable planning of food and money crops and to horticulture and backyard farming; the encouraging of a larger cultivation of those crops which are likely to make up for the deficiency in the national diet, e.g. pulses, soya beans (milk, cheese and cakes prepared from them for both

man and cattle), ground nuts, wheat, etc., if necessary by offering concessions to the ryot in the form of remission of revenue assessment; and, finally, the introduction of suitable marketing and distributing machinery by means of co-operative seed stores, storage and selling organization. It is the duty of the State to initiate and organize these improvements. Drainage and irrigation are vital factors in land reclamation and utilization, which must be looked after by the State.

Nutrition surveys have been and are now being carried out in various parts of India. A lot of facts is known to us by now but it is a matter of great regret that these surveys do not often step out of theoretical and academic into practical and applicable domains.

Sir John Russel in his Report on Crop Planning (1937, pp. 16–22) has said that 'the well-balanced diet does not require more but less cereals than at present, but it includes more of everything else, especially of vegetables, fruits, and milk, and one great need for the food supply is to increase the production of these three essentials, therefore, to increase the yield of the staple crops so as to liberate land for the cultivation of these supplementary foods. No improvement in "quality" of the cereals or pulses will convert the ill-balanced into a well-balanced diet. I am strongly of opinion that in dealing with food crops intended for home consumption the agriculturist should aim at securing the largest and healthiest crops possible, but that he need not concern himself with trying to change their consumption. The amount of alteration possible is too small to justify the expenditure of time and resources that can better be spent in other ways'. With a view to secure a co-ordination between nutritional research work and agricultural research, a Nutrition Liaison Officer was appointed some years ago, which step pleased Sir John Russell very much, but alas! before this officer could make any headway, the post has been abolished. This is one of the ways in which our relations between theoretical and applied science are maintained in India.

It has been shown above and elsewhere (Food Planning in Bengal, Report of the Food and Nutrition Exposition, Calcutta, 1939, pp. 42–50) that the peasant has to raise his income three times his present income level in order to enable him to obtain the minimum requirements of a healthy life. The problem is how is he to raise his food and to obtain his resources for the other necessities of life? Any scheme of food planning, therefore, must not only take into consideration questions of improving the quality and quantity of crops, i.e., improvement of agricultural methods and crop planning (here lies the field for co-ordination between Agriculture Department and Nutrition Workers), the improvement and availability of the soil (here lies the field for co-ordination between Drainage, Irrigation, Communications and Agriculture Departments) and the improvement of cattle and dairy produce but also the associated but complex problems of industrialization (large-scale and cottage) and population control by emigration and birth control in order to relieve the pressure of the increasing population on the soil. The development of industries subsidiary to agriculture, as has been done in Japan where the silk industry has become an important subsidiary occupation of agriculture and accounts for 20% of the income of the agricultural classes, may be attempted here. The exploitation of man power during non-working agricultural seasons (approximately 4 months in the year) in subsidiary occupations might offer some solution. Associated with this also is the problem of improving the positive health of the people and of increasing their physical fitness and working capacity.

Adulteration is an important matter. Legislation regarding adulteration and grading of food products (e.g. milling of cereals) may be necessary.

It will be seen from what has been said that a planned programme of the development of food production and conservation is to be followed in every province, if we wish to protect the population from further deterioration. The activities of the various departments of the Government—Agriculture, Irrigation, Veterinary, Co-operative, Industries

and Education—have to be pooled and co-ordinated and thus brought to the ryot's rescue. In most provincial Governments in India such co-ordination is not easily secured, with the result that our efforts become disjointed and slow and they do not form part of a planned programme. It is needless to say that such a national effort to save the semi-starved population requires a national planning by the State and the people.

The speaker suggested that a Food Planning Committee should be established in every province in co-ordination with the Agriculture, Irrigation, Veterinary, Co-operative, Industries and Education departments, to study the food position in its respective areas, to find out where the lag was and to take suitable steps to remove the lag wherever it was detected. The Provincial Sanitary Board in Bengal has already led the way by appointing a Nutrition Committee, which is trying to study the problem in all its bearings and I hope that the much-needed co-ordination emphasized by me will be soon forthcoming.

2. Dr. W. R. Aykroyd, Coonoor.

The idea that scientific knowledge of food requirements should be taken into consideration in planning agricultural policy had been gaining ground within recent years. In England the war-time food policy, in respect of both imports and home production, had been influenced by modern ideas of what constitutes a satisfactory or adequate diet. If this aspect of food planning was to be developed, it was necessary to have reliable data about the dietary habits of the population concerned and how these could be improved. A great deal of data of this nature had already been collected in India. Within the last 6 years some 70 or more detailed diet surveys had been carried out in various parts of India, which showed very clearly the defects of typical Indian diets. First, there could be no doubt that a high percentage of the population was under-fed. 'Enough food' took precedence over 'the right kind of food', and it followed that to produce more food must be the primary aim of agricultural policy. Secondly, most Indian diets could be improved by the inclusion of such foods as milk, pulses, vegetables (particularly green leafy vegetables), fruits and fish in greater quantities. A striking increase in the production of milk products was at present difficult for a number of reasons. But something could be done with regard to pulses and this question was at present receiving the attention of the Imperial Council of Agricultural Research. Vegetable growing could be stimulated in various ways. More attention should be given to this question by agricultural research departments. The education of the people about the value of green leafy vegetables was highly important. Again, the sea-fishing industry remained in an undeveloped state and a potential source of valuable food was largely untapped. In this connection, the recent development of centres for the production of shark liver oil as a substitute of cod liver oil was of considerable interest and importance. This was in a sense food planning, based on the findings of nutrition research.

The nutrition worker put forward his views about the direction in which food production should develop in order to improve the diet of the people. It was then the task of agricultural research workers and departments to study the means of putting these recommendations into effect. Conversely, it might be shown that agricultural research on which a great deal of time and money was being spent was not likely to raise standards of nutrition. Closer contact between agricultural and nutrition research would benefit both and encourage the use of the scientific method in the attack of many formidable problems.

3. Mr. K. Mitra, Patna.

(1) Before any planning of food for masses in India be taken up it is desirable that an assessment of actual yield of the agricultural produce

in the country be made. Usually the data about the produce of milk, meat, fish, poultry and vegetables, in other words, the essential food factors are not available.

(2) Increment of the food resources of the country should be accompanied by efficient marketing organization so that the foodstuff may be placed within the reach of the poorer consumers at a reasonable cost all over the country.

(3) Dr. Aykroyd has very rightly pointed out that any reasonable increase in milk production is not possible in this country under the existing circumstances. Though the majority of the people are vegetarians, still a very large amount of population have no aversion to meat or fish provided their economic status allows the inclusion of this item in their food. The fisheries should be tapped more efficiently and the question should not be shelved on the grounds of vegetarianism alone.

(4) A rice-eater's diet can be balanced to a very great extent by inclusion of leafy vegetables. These leafy vegetables can be grown in the back-yard of every family unit at a very little or insignificant cost. This item is likely to improve the intake of calcium, vitamin A and vitamin C.

(5) The speaker has often been asked as to how one could make digestible the comparatively indigestible millets like ragi, jawar and flowers of Mahua (Bassia latifolia) which are not considered fit for consumption by certain sections of people. At Coimbatore, malting of the inferior millets was being carried out. This knowledge should be made available to the people at large.

(6) The speaker would endorse the valuable suggestion made by Dr. Ukil as regards the improvement of agriculture by extension of the irrigation facilities. In India still large tracts of land are lying comparatively fallow or at best only one crop is being raised for paucity of water. This side of the question demands serious attention by those who contemplate increased food production for the population.

4. Mr. J. N. Maitra, Calcutta.

Spoke on the necessity of food production and food preservation, in addition to the control of food export by legislation, if required. He thought that by suitable education of the masses in schools and outside institutions a good deal of the wastage of valuable elements in food could be minimized.

5. Dr. K. V. Giri, Vizagapatam.

Stated that experiments carried out at the Coonoor Laboratories have shown that the Indian gooseberry (*Amla*) is a rich source of vitamin C, so much so that one or two grammes of the powder or a single fruit could supply the normal requirements of an adult individual. He thought that its cheapness and easy availability offered an easy method of supplying vitamin C to our population.

6. Mr. A. K. Banerjee, Calcutta.

Nature's supply of food for men as well as animals is not inadequate. Moreover nature is always trying to maintain a balance between demand and supply. It is man's own uneconomic and thoughtless way of using the resources of nature that has caused him, as well as his animals, so much distress and difficulty. This can be illustrated by taking one item of diet—namely, fish, which occupies not only an important but a necessary item in the menu of the rice eating population of Bengal. Bengal is a land of rivers and possesses the large area of water surface in comparison with other provinces. Fish can be obtained in large quantities during certain seasons at almost any place near the principal rivers. But in Bengal there is a great clamour for want of fish and what is this due to? This is

due mainly to (i) intensive fishing in small areas, (ii) using nets which have very small mesh and thereby trapping the small fry, (iii) lack of knowledge as to the netting of millions of carp eggs which flow down to the saline water in the estuaries and die. The second point in support of my argument is that the vast area of the Sundarbans, possessing a vast network of water channels, rivers and canals, is a mine of fish which has a very great potential market as well as food value. But for want of proper organization amongst the fishermen, for want of facilities of transport and communication, this nature's valuable wealth of fish is not being utilized at all. At the modest computation, the city of Calcutta needs about ten to twelve lacs of fish annually whereas the citizens get a supply of about two lacs only. Again, a considerable quantity of supply is wasted due to putrefaction. By way of remedy I may suggest a few points to the members of the food planning symposium for their kind consideration: (1) attention of the Department of Industries and Agriculture to be drawn in respect of fish culture and fish preservation, as well as netting of fish. The work so far done by the department leaves ample room for improvement. (ii) The Universities of Calcutta and Dacca are to be requested to set up a body of research workers from amongst men in the departments of zoology, geography and medicine who would carry out research work in the form of field work, study the distribution of fishes, in the form of laboratory work, to find out the possibilities of artificial hatchery and to study of market conditions. (iii) Preservation and storage of fish is another very important item. None of the markets of Calcutta possesses any refrigerating plant. Billingsgate market in England, which sells 400 tons of fish daily on week days has a very good arrangement for cold storage, boiling and other means of preservation. Hence, if we can stop the wastage, I think we can add more biological protein to the food of the masses.

7. Mr. K. Ramiah, Indore.

The question of educating the people with regard to healthy foods and food habits has been stressed by some of the previous speakers. He was, however, doubtful of the effect of education. He quoted the instance in Madras where some years ago a co-operative society was started to produce and sell to its members hand pounded rice but so far as he knows, it did not make any headway even with educated people. He did not see any reason why legislation should not be thought of to prevent people obtaining less nutritious food, for instance, the production of mill polished rice could be prevented by legislation. When legislation has been found useful and appreciated in the social matters, for example Sarda Act, there was probably greater need for legislation with regard to foods.

As regards crop planning he stated that no one had any doubts about its necessity or usefulness. What the absence of such planning has brought about in our own country with regard to sugarcane was known to everyone but the problem was beset with considerable amount of practical difficulties. A certain amount of successful planning has been done with regard to some of our plantation crops, such as coffee and tea. Due to variations in climatic conditions and natural facilities available in different tracts of the country, the productive capacity also varied. Was it possible to say that only such tracts that had the facilities and suitable conditions to produce the maximum outturn per acre of any particular commodity should be allowed to produce it and others where much facilities are lacking should be prevented from producing it? Such a proposition immediately brings up the question of the economics of crop planning in particular tracts and interprovincial and interstate controversies. There is unfortunately an increasing tendency for self-sufficiency in provinces and States. Even if such a planning were possible for the country as a whole steps might be necessary to prevent other countries which have facilities to produce a particular commodity in

greater abundance and sometimes even at a cheaper rate from dumping the commodity in the country and upset the arrangements.

8. RAO BAHADUR B. VISWANATH, New Delhi.

The speaker thought that there was just enough protein for two-thirds of the population of India and that it required 5-6 acres of land per family in order to obtain the necessary quantity of biological protein. He agreed that while more land should be made available for increased food supply, more production, particularly of the protein foods, from the available area of land was greater necessity. He therefore appealed for more food production first and then of protective foods. In this task he thought that the nutrition workers should inform the agricultural workers of the requirements of the population and then the latter would devise ways and means for ensuring the required production. He thought that this co-operation was very much needed in India to-day.

9. DR. V. K. BADAMI, Cuttack.

Thought that the same story of shortage of food and excessive population in relation to the available land prevailed everywhere in the rural areas. The problem was how to put the scientific principles into practice and he thought that in this task the State and scientists should put their shoulders together.

10. MR. K. J. DEVADANAM, Baroda.

Drew attention to the successful work in this direction being done by the students in educating the villagers, which, he hoped, might be emulated elsewhere.

The president, Mr. P. M. Khareghat, in winding up the discussion, pointed out that the subject of Food Planning could be considered under two aspects: (1) the food that should be consumed, and (2) the supply of such food; the latter touched on the subject of crop planning.

So far as the suitability of the food consumed was concerned, the nutrition workers had given us a fair idea of what was required to maintain the people in health. The practical difficulties were in connection with (i) the poverty of the people, (ii) changing over from a diet to which the people were accustomed, and (iii) the availability of the type of food required.

The suggestion had been made that the existing food should be improved by putting into it the required additional nutritive elements by judicious breeding, proper manuring, etc. This was, however, very difficult in practice and he agreed with Dr. Aykroyd that we should for the present direct our main attention to the supplementing of the existing diets. This meant that suitable additional crops, such as pulses, should be grown. This again brought in difficulties connected with soil, climate, etc., and there was also the question of the availability of more land. The solution lay in making the existing land produce more per acre, so that the same quantity could be produced from a smaller area and then to utilize the area thus made available for the production of additional crops or fodder required. If this was to be done effectively and intelligently it meant crop planning.

As regards the planning of crop production he thought that there were serious difficulties, but there was no reason why an Advisory Body or Organization could not be set up to survey the whole position regarding food production and supply in the provinces and States and to consider the question in its various aspects as regards the available land, the nature and quantity of crops, additional or otherwise, which could be produced from it, the education of the ryot in the improved methods of

food production and preservation, etc. His own impression was that the ryot would listen to the scientist if the latter could guarantee him against loss. He thought food preservation to be an important means of conserving food resources in an area, e.g., mango could be thus preserved and used when the fruit became scarce. He did not agree with those who thought that the production of more milk for the population was not a practicable proposition at present in India, as had been proved in Rajputana. The difficulty lay in educating the people to drink more milk.

He thought that the Advisory Body suggested above might help the Local Authorities to solve their difficulties by offering suitable advice in planning in their respective areas. These efforts might have to be supplemented by legislation, where persuasion failed. He endorsed the suggestion that there should be greater co-ordination between the agricultural authorities on the one hand and the nutrition and public health authorities on the other. He mentioned that a good deal of that co-ordination already existed, as the Public Health Commissioner was on the Advisory Board of the Imperial Council of Agricultural Research, while the Agricultural Commissioner was a member of the Nutrition Advisory Committee, Indian Research Fund Association.

XXI. REASONS FOR THE LAG IN INDIA OF UTILIZATION OF MEDICAL KNOWLEDGE BY THE INDIVIDUAL AND INITIAL STEPS TOWARDS SOLVING THE PROBLEM.

(Section of Medical and Veterinary Research, and the Sub-Committee on 'Science and its Social Relations'.)

PROF. D. D. KANGA, Madras, presided.

1. MR. A. C. UKIL, Calcutta, opened the discussion.

The speaker pointed out how the industrial revolution in the West opened up new vistas of possibilities for their application to the mental, moral and physical well-being of man and how persistent State action, aided by concurrent economic, social and political progress, proceeded side by side to develop the environmental and medical services in these countries. The evolution of public health, as is understood in modern times, may be divided into three distinct phases :– (i) the period of empirical environmental sanitation, between 1840–1890, (ii) the period of scientific control of communicable diseases by the application of the microbial causation of diseases, between 1890–1910, and (iii) the period of sociological medicine, during the last thirty years.

The successive scientific advances enabled a fuller apprehension of positive health, heralded the emergence of sociological medicine and profoundly affected the action and purpose of statecraft. Political and economic advance was followed by legislation and State action on the improvement of working conditions and occupational hygiene, school health including the provision of school meals and preventive treatment of defects, the prevention of maternal and infant mortality, health, unemployment and invalidity insurance, immunization against disease, the provision of better and safer food, and the prevention and care of mental deficiency, tuberculosis, venereal diseases and cancer. Subsidized housing and town-planning schemes made it possible for the eradication of slums,

the construction of sanitary dwellings, the provision of cheap-rental houses and the abatement of overcrowding, resulting in a great improvement in sanitation and cleanliness. The result of studies through these stages has led to the development of Medicine fundamentally as a Social Science, wherein is applied practically every basic science directed towards a comprehensive programme of community service, including the maintenance of health and prevention of disease. The cure of disease in such a programme becomes less voluminous in proportion to the rate of progress in the utilization of scientific tools for human welfare. It was pointed out that the failure to establish scientific methodology in determining tools for community welfare was one of the chief factors for the present social lag throughout the world.

The speaker emphasized the importance of applying the following essential principles for ensuring a sound public health administration:—

(1) The different health functions for the whole community should be undertaken by a single governing body with necessary co-ordination between inter-related departments, aiming at 'Centralized direction and decentralized activity'. There must be provision for efficient technical supervision and periodic appraisal of the efficiency of the organization.

(2) Successful administrative procedure should be used on scientific investigation and demonstration of organizational methodology in the measures whereby knowledge can be applied in practice to groups of population. Arrangements should exist for the proper training of the necessary personnel in applying such methodology.

(3) Successful administrative procedure must be based upon sound financial considerations and practicable economic budgeting suited to the area and the population.

(4) Successful community utilization of knowledge for public health reform and medical protection requires a certain level of politico-economic progress and education, for the health of the people is achieved through the people being themselves possessed of adequate education in, and practice of, health knowledge.

(5) Owing to the mutual inter-dependence of the inter-related spheres of social services, the requisite co-operation between them should be fully secured.

(6) In order to ensure better working and to avoid mistakes in local effort, the *whole design* of a public health planning must be before the mind from the very beginning. Any scheme, however small and localized, can confer benefit, if it is designed in relation to the scheme as a whole. Any public health planning which is not based on sound scientific and proven principles is bound to fail.

It was shown that India stood, at the present moment, from the public health point of view, where Great Britain stood 100 years ago, U.S.A. stood 75 years ago and where Russia stood before the Revolution (20 years ago).

In tracing the trend of public health progress in British India, the speaker pointed out that while persistent endeavours were made in countries like England to apply the knowledge gained from scientific discoveries in developing the environmental and medical services, they were relegated to the background in India owing to the absence of any national health policy, the violation of the essential principles of sound public health administration, the backwardness and lack of methodology in education, defects in the training and supply of technical personnel, inadequate scientific investigation of scientific problems, lack of supply of drugs and scientific appliances, lack of institutional planning, lack of co-ordination between the inter-related departments of social welfare and various financial handicaps to progress, such as the low economic level of the population, inadequate allocation of revenue to social welfare services and the maintenance of a top-heavy organization. On comparing

the revenue allotments for State expenditure in England and India, it is at once apparent that in India the social welfare services, like education, medical and health protection and agriculture and veterinary work, are starved at the cost of the allocation on defence, police and jails, etc. In support, the following figures were quoted:

Expenditure per cent of total revenue under the following heads.

	Defence.	Police.	Jails.	Education.	Medical and Public Health.	Agriculture and Veterinary.
England, Wales and Scotland..	27·3%	4·0%	0·1%	18·2%	22·7%	1·4%
British India (Central and Provincial) ..	34·0%	8·0%	1·3%	8·4%	3·4%	1·7%

The backwardness of India in health matters does not seem to be due so much to economic causes, ignorance or lack of medical facilities as to the lack of an efficient public health and medical organization based upon the most effective and economic methods of applying the results of scientific knowledge to the requirements of large units of population. The backwardness is also due to the lack of scientific outlook and an inadequate investigation by the administrative authorities in developing suitable methods of organization and the lack of a policy to include both rural and urban population in a cognate whole. In the maintenance of health, the State must provide for a social machinery to assure living standards adequate for the purpose. The problem in India to-day is how to remedy the lag between scientific progress and its application to the benefit of the individual and the community, how to adapt our medical education to the needs of the changing socio-economic and political environment and how to train the necessary technical personnel for carrying out the national health programme and to supervise its various units. Medical education needs a thorough reorganization adapted to the new requirements. Social science should be given an adequate importance in the curriculum. The Universities have hardly taken any initiative in organizing medical and veterinary research which is also shabbily treated and badly organized by the State. Researches have been carried out on many diseases in India but very few of them have been undertaken to solve specific health problems and, even when the results of such investigations have been made known, there has been little attempt to apply them into practice. It is of the utmost importance, therefore, that this country should try to make up the scientific lag and make a general survey of the state of public health and of its health equipment, evolve a methodology of approach by carrying out sample experiments in different areas, to understand the reciprocal co-ordination between the inter-related departments and its financial implications and, based on such findings, construct a coherent plan for a medico-social policy, fixing, year by year, the stage to be reached and securing the financial resources, in cash and/or kind, and trained personnel required for the purpose.

He then discussed the essentials for the planning of public health in the federal sphere and in provinces, with special reference to Bengal. The 'First Steps' in a province, will be for the department of Rural Reconstruction, which should be a co-ordinating department, in every province to set up a Planning Committee, with sub-committees on Social Welfare and other technical fields of rural reconstruction. The 'terms

of reference' should be to define clearly the objective, to advise on the best way of developing and demonstrating the methodology of work proposed, to determine the method of training of the required personnel and of proper supervision, control and maintenance of their level of efficiency, and to suggest the best means to secure the co-operation and co-ordination of the inter-related departments.

If the suggestions put forward are looked at from a constructive view-point, the Rural Reconstruction departments in the various provinces will be expected to move in the matter and to determine what steps are practicable in applying the various principles for efficient and adequate medical protection in their own territories.

The training of personnel and the financial implications of such a scheme within the budgetary capacity of the provinces were indicated as follows:

Any scheme in which the overhead charges exceed 30% of the total earmarked budget is financially unsound. Hence, the salaries of the services should be adjusted according to the income per head and taxable capacity of the people.

The close participation of the Rural Reconstruction Department, which aims at co-ordinated uplift of the population by all the branches of the administration, will not only speed up the public health progress but will save a considerable expenditure for social-*cum*-public health advance. Any planning in public health is closely related to the general national planning.

It is understood that the construction of the quarters for the health personnel and of the hospitals and clinics will be undertaken by the local population. It will serve the purposes of national planning, if cheap materials which may last for, say, 20 years or so are utilized in the construction of houses and institutions. Russia was compelled to adopt this for economic reasons in the initial stages of planning. If the methods of national planning succeed, it may be possible to replace the temporary structures by more permanent materials at a later stage. It is also understood that the local population will voluntarily and actively participate in improving personal hygiene and environmental sanitation.

The idea is that both curative and preventive services should form a co-ordinated whole, ensuring every rural family a minimum of attention, especially in cases of confinement, infectious disease or accident and in those requiring urgent medical aid. The aim should be to prepare a stage-wise and co-ordinated programme 'covering at one and the same time both central and local administrations, both environment of the family and the individual, both preventive and curative action'.

The provincial organization, under the three heads of administration, urban and rural service and training of personnel in experimental and community field training centres, has been proposed to be placed under a Ministry of Social Affairs with a Director of Public Health or Social Affairs directly under him, which will secure intimate co-operation and co-ordination, through the Department of Rural Reconstruction, with the Department of Education, Department of Agriculture, Co-operation and Animal Husbandry, Department of Industries and Department of Communications and Irrigation. As curative medicine occupies a small portion of modern preventive medicine, the posts of the Surgeons or Inspector-Generals and of District Civil Surgeons have been proposed to be abolished. The direction, control and supervision will extend from the provincial headquarters to the peripheral units, comprising of two Union Boards and a population of 20,000.

The peripheral units will have a clinic and dispensary with 5 beds and are expected to deal ordinarily with the correction of minor defects and ailments, along with activities in connection with physiological health. 4—5 peripheral or primary centres will constitute the next higher or Thana Centre, which will have a hospital of 50 beds. This will be linked up to the next higher unit or Sub-divisional Centre with a

100-bed hospital and Field Training Centre for junior personnel. The sub-divisional centres, in their turn, will be connected with the more highly developed District Centre, with a 250-bed hospital, experimental training field for the next higher type of personnel and an attached medical school. The district health administration constitutes a link between the provincial and local administrations. The Provincial head-quarters will provide for the training of the superior personnel and specialized services and will organize research activities for solving public health problems offered by the district and subsidiary units.

The recurring annual expenditure of a peripheral or Primary Centre will be Rs.3,000 per annum, that for a Thana Unit Rs.10,000 per annum, that for a Sub-divisional Unit Rs.50,000 per annum, and that for a District Centre Rs.1,000,000 per annum. This gives us an expenditure of about Rs.2 crores for the rural public health organization in all the districts in Bengal. To this should be added the cost of central or basal supervision and training centres—Rs.100,000 per annum. Rs.20 lakhs per annum will be needed for 4 Medical Colleges in the four Divisions of the Province for training the medical and public health personnel. Besides these, a certain amount of capital expenditure (about Rs.5 lakhs) will be needed for equipping the institutions with instruments, appliances and drugs. The development of the Social Assistance machinery is an urgent necessity in the furtherance of public health. The expenditure on this head cannot be visualized at this moment.

Let us see how the expense can be met. The urban population in Bengal is only 1/16th of the rural population. Yet the per capita expenditure on curative and preventive services in municipal areas is Rs.2-1-9, in comparison with only 4 annas and 4 pies in rural area. In order to divert more money to rural areas, the Government contribution to municipal areas will have to be starved for some years. Excluding municipal areas, the Government contributions at present (1940-41) Rs.87,83,000, the District Boards Rs.35,38,000 and the Union Boards Rs.14,21,403 or a total of Rs.1,37,42,403 to preventive and curative services. Thus there is a deficit of a like amount in financing the suggested scheme. This can be made available from various sources. One of them is more Government allocation to social welfare services. Out of a total per capita expenditure of Rs.2-7-5 in Bengal, Police expenditure absorbs 8 annas and General Administration and Administration of Justice together absorb 8 annas 6 pies per capita or a total of more than a rupee per head, while only 4 annas 6 pies per capita is given for education and 3 annas per capita for preventive and curative health services. Compare this with the per capita expenditure of Rs.35-9-0 for education and Rs.6-9-0 for medical relief and public health in England and Wales. The other inter-related social services in provincial budgets are similarly starved at the expense of a top-heavy and maladjusted administrative machinery.

The scheme, the speaker thought, could be made practicable if the cost now being paid by the Government, District Boards and Union Boards was doubled. The present per capita expenditure from these sources is 2 annas 9 pies, 1 anna 1 pie and 6 pies respectively or a total of 4 annas 4 pies. By doubling the figures, the respective contributions will be 5 annas 6 pies, 2 annas 2 pies and 1 anna or a total of 8 annas 8 pies. The municipal expenditure is left out of account. This is the minimum from where a start can be made. Provided the willing co-operation of the population is secured, enough contributions in kind will be available for the expansion of the scheme.

The initial steps in planning can be undertaken in Bengal if the cost on public health and medical protection now being paid by the Government, District Boards and Union Boards are doubled, i.e., at a per capita expenditure of 5 annas 6 pies, 2 annas 2 pies and 1 anna respectively or a total of 8 annas 8 pies per head of the population, provided proper co-ordination and co-operation are secured with the inter-related departments of Education, Agriculture, Co-operation and Animal Husbandry,

Communications and Irrigation, Industries and Rural Reconstruction. In such a scheme, the overhead charges on establishment should not exceed 30% of the total earmarked budget, as it will be a financially unsound policy to do so.

The provincial Governments should set up, as a first step, a Planning Committee, the terms of reference being to define clearly the objective, to advise on the best way to develop and demonstrate the methodology of work proposed, to determine how best to apply the same in the wide fields around, to determine the method of training the required personnel and of proper supervision, control and maintenance of their level of efficiency and to suggest the best means to secure the co-operation and co-ordination of the inter-related departments.

2. LT.-COL. A. C. CHATTERJEE, Calcutta.

Reasons for the lag.

1. Abandonment of social and religious injunctions—

Old social and religious injunctions, many of which were hygienic in nature, have been given up but the new scientific principles have not been taken up.

2. Changes in social order—

Changes in society, both communal and racial, have occurred which have complicated the problem and raised new issues.

3. Lack of directions—

No one has pointed out the essential necessity of the individual as well as society of adapting itself to the changing conditions, and how such adaptation may be done.

4. Lack of Health Education—

No systematic and proper health education is given—particularly in schools. Neither Environmental Hygiene nor Personal Hygiene impressed or implemented—particularly Personal Hygiene which is the real basis of all improvement of health.

5. Absence of a National Health Policy—

There has been up till now no national health policy. It is partly due to lack of sufficient reliable data and consequently lack of knowledge regarding comprehensive methods that may be adopted. People also were too apathetic, partly due to continued effect of disease, lack of proper nutrition, economic backwardness, and partly due to complacency in the name of religion and fatalistic outlook (stereotyped organization), semi-starvation. There was no State drive to wean the people out of this morass of degeneration.

6. Changes in political administration—

Political unsettlement is an important factor in impeding progress in this line and, as a result, there has been no comprehensive research and demonstration. There was no definite and sustained policy of the centre to meet the requirements of the country. Too much attention was being given to politics.

7. Lack of co-ordination of work—

As a corollary to the absence of a definite and sustained policy, lack of co-ordination of work was inevitable.

8. Lack of co-operation between Departments whose activities have a bearing on public health, such as between Public Health, Education, Agriculture and Communications.

Initial Steps of Solution.

1. A clear conception of the present-day socio-economic condition of the country is necessary, which is variable to a certain extent from province to province.

2. A comprehensive National Health Policy to be enunciated from the Centre—Formation of a Ministry of Social Welfare which would combine Curative and Preventive medicine in all its aspects, improvement of physical fitness, social activities such as housing, provision of nutrition to school children and needy pregnant and nursing mothers, Health and Unemployment Insurance on a contributory basis, old age pensions, organized State help and charity, establishment of Workhouses and Industrial Homes for the indigent, training of Public Health (which includes Medical) workers and of personnel of the auxiliary services. Central Advisory Board of Health.

3. Provinces to implement the policy with such adaptations as required to meet local needs. Present Public Health (which includes Medical) organization for such implementation is wholly insufficient and requires complete and comprehensive reorganization.

4. Creation of public opinion about a National Health Policy by a concerted drive.

5. Replanning of the educational system to meet the changed conditions and new way of living so that a more useful citizen is evolved who will demand a better and higher standard of living.

6. Intensive health education amongst school children and the adults with practical implementing in which the teachers must take an active part, particularly in the schools. Proper books on health education are needed. A planned scheme should be evolved to suit each province and make use of all available media for imparting such education.

7. Enacting of Public Health Acts and Manuals—central and provincial—strengthening the position of public health executive staff by giving them statutory powers by legislation so that preventive work may be carried out with a sustained effort and intensified.

8. Compulsory teaching of Hygiene in all the classes of school period.

9. Socio-economic aspects of Hygiene should be stressed in the High Schools.

10. Compulsory examination in Hygiene in the Matriculation and School Final Examinations—matriculates to get their certificates only after actively participating for a period in a programme of health education amongst the masses and the primary schools.

11. Organization of suitable personnel and machinery for making up the lag and avoid the deficiency in future:—

(*a*) Practical socio-economic aspects of Hygiene to be studied in Medical Colleges and Schools and Social Workers' (which include Nurses and Health Visitors) Training Institutions;
(*b*) Training of School Nurses;
(*c*) Inauguration of School Nursing Service;
(*d*) Reorganization of Rural and Urban Public Health Services;
(*e*) Organization of Mental and Industrial Health Services;
(*f*) Evolution of a polyvalent medical-social worker.

12. Introduction of National Health Insurance in the provinces in restricted group first and then gradual expansion.

13. Enactment of constructive social laws and regulations which would help in the organization of the society on a planned basis.

14. Finance—

(*a*) Central Government to give grants-in-aid—particularly for research in methodology (Teaching and Demonstration).

(*b*) Grants-in-aid by Provincial Government to—
(i) Local bodies and voluntary organizations on a *pro rata* basis for social activities, e.g., housing, nutrition schemes, school medical inspection, medical relief and health education;
(ii) Establishment of training institutions;
(iii) Financing of health and unemployment and old age pension schemes;
(iv) Finances of organized State help and charity and establishment of workhouses, etc.

15. Encouragement of voluntary co-operative organizations which try to improve physical and mental health.

16. Co-ordination of work of all those departments whose activities have a bearing on public health such as that of Communications (including railways and shipping), Education, Agriculture, Public Health and Industries.

3. Rai Bahadur K. N. Bagchi, Calcutta.

The reasons for the lag of utilization of medical knowledge by the public have been described by Dr. Ukil in his presidential address and any attempt to discuss this question is likely to be a repetition of his statements. I would, therefore, touch upon certain factors which he did not discuss in detail in his address.

The utilization of medical knowledge by the individual implies two factors, viz. (1) the capacity of the individual to imbibe the knowledge, and (2) the capacity of medical men to propagate it by popular methods.

(1) *The capacity of the individual to imbibe medical knowledge :—*

The causes that stand in the way of acquiring medical and public health knowledge by the individual are many but the following are more important :—

(i) The defective system of education in the country—extending from the primary education imparted to little children right up to the top—the finished product of the university. The school children are made to learn something of everything including elementary science and hygiene but the method of teaching is so unscientific on account of having no laboratory for practical work and the capacity of the teachers in dealing with scientific subjects is so poor that the students do not find any interest in these subjects and they pass out with an absolutely blank mind although they commit to memory all about the cause and spread of malaria, cholera, small-pox, etc. The so-called educated people or, in other words, the graduates of our universities get the much coveted degree mostly by cramming. They seldom show power of observation and discrimination or possess a strong common sense. Very few care to learn anything outside the prescribed syllabus. The 'arts men' hardly take interest in scientific matters even renderd in popular forms. The utilization of medical knowledge by such people at their own initiative is, therefore, unthinkable. In this respect they offer sad contrast with average European students.

(ii) The traditional superstitious ideas and the unscientific teachings of other systems of medicine regarding the cause and spread of infectious diseases, for example, are frequently antagonistic to scientific truths but they are so deeply

ingrained in the minds of even the most educated people that they cannot be shaken off.

(iii) The large number of quacks of all systems of medicine practising in rural areas are instrumental in propagating the time-honoured superstitious and erroneous ideas. They mix with the public more intimately on account of their cheapness and easy approachability. The half truths or untruths if repeated frequently are taken as truths and as such the scientific truths create no impression on them and make room for superstitious beliefs propagated by these people indefinitely Young people brought up in villages in such an environment are not likely to get rid of those queer ideas and to accept the scientific principles of medicine and public health.

(iv) Intelligent medical men with scientific trend of mind and up-to-date knowledge in preventive medicine who are competent to disseminate medical knowledge are always anxious to settle down in big towns and seldom in rural areas which are the nurseries and training grounds of 95% of the population. Even when they settle in villages, they cannot mix with the people so intimately as the quacks do—the superiority complex stands in the way. Thus in the fight between the unscientific teachings of the quacks on the one hand and the scientific principles of preventive medicine taught by qualified medical men on the other, the former always win on account of the overwhelming number, the persistency and approachability of their sponsors.

(v) The uneducated or illiterate people are believed to be incapable of imbibing elementary scientific ideas and as such the lag is usually attributed to illiteracy prevailing in the country. It is partly true but is not the whole truth. It is frequently observed in the countryside that the old system of inculcating religious ideas among the masses by what is known as "Katha", i.e., teaching through talks, stories and songs, works very well and I have personally known illiterate persons acquiring in this way a fair conception of teachings of various Hindu scriptures. What is possible with religious teachers are not likely to be impossible with scientific men for propagating scientific knowledge. What is wanted are capable teachers and a system of teaching which may appeal to the illiterate village people.

(2) *The capacity of medical men to disseminate medical knowledge* :—

The capacity of a medical man to help in the diffusion of medical and public health knowledge among the masses depends on (1) his sound knowledge of the subjects concerned, (2) his ability to make it popular by introducing talks and stories into the subject-matter, (3) his ability to study the capacity of the learners according to their age, sex, intelligence and education, (4) his capacity to mix freely with all classes of people without assuming an air of superiority, and (5) his ready wit and sympathy.

The possession of a sound medical knowledge with special reference to preventive medicine by an average medical man is rather a rare phenomenon in these days. The existing system of medical education in some of our universities is far from being desirable. The following defects may be mentioned—(1) inadequate teaching of basic subjects such as, physics, organic and biochemistry, physiology and anatomy in the preclinical stage and preventive and forensic medicine in the clinical stage, (2) inclusion of too many subjects in the curriculum and consequent neglect of more important subjects, e.g., inclusion of pharmacology (with materia

medica and pharmacy), toxicological chemistry, elementary pathology and bacteriology in the group along with anatomy, physiology and organic chemistry as lately introduced in Bengal, (3) appointment of inefficient and inexperienced demonstrators (on short term contracts—sometimes on a paltry sum of Rs.50 p.m.) for purposes of economy, (4) too frequent change or transfer of demonstrators—preventing them from gathering experience in the art of teaching, and the most important of all is (5) the absence of museum for purposes of demonstration specially in preventive and forensic medicine. A Public Health Museum, like the one in Dresden in Germany, goes a long way not only in teaching medical students but also in the diffusion of public health knowledge among the masses. It is high time that the importance of museum in teaching scientific subjects should be realized by the State, the university and the public.

The remedy lies with the Indian Medical Council which should not rest satisfied with merely wresting powers from the vested interest but exercise them judiciously in the constructive side of the medical education in India. It should show a little more alertness of perception and enforce its authority on the universities which are responsible for gradual deterioration in the quality of our medical graduates. It should not allow further lowering of standard which is bound to follow, in course of time, since the New Regulations have been introduced without making necessary provisions for teaching of basic scientific subjects up to the required standard, as has lately been permitted in Bengal. There has been no change in the syllabus of physics or chemistry in the I.Sc. course and the students admitted in medical colleges under the University of Calcutta since 1940 and also in other universities, do not possess the faintest idea of chemistry of important metals, such as, arsenic, bismuth, antimony, manganese, barium, radium, etc. The reduction of the period of training in medical colleges from 6 to 5 years, as has lately been done, would do no good whatever to the students but would definitely lower the standard and produce graduates no better than ordinary licentiates. Larger number of subjects treated in a shorter period would cripple the mind of young students and induce cramming. The Calcutta University prescribes only 30 lectures for teaching organic and physical chemistry (up to B.Sc. standard) and '25 lectures or demonstrations for pharmacology including materia medica, practical pharmacy and toxicology'. The result of such a course of training may better be imagined than described.

The production of this type of medical men is not likely to help in the utilization of medical knowledge by the individual. They may be safely appointed as lecturers in medical colleges where they would dictate notes to the unwilling listeners in lecture theatres, but they are not likely to be useful in popularizing medical knowledge among the masses. The best products of the university may be competent for this purpose but these ambitious young men are not likely to settle in rural areas.

It may be contended that for teaching illiterate masses in villages, an ordinary medical man without any special aptitude in basic and public health sciences or in medicine and obstetrics, may serve the purpose quite nicely. I do not contribute to this view. Such a medical man would only hoodwink the masses and perhaps propagate newer kinds of half truths among them. Unless he possesses a sound and clear knowledge of the subjects he would teach, he cannot successfully take part in discussions and he is sure to be found out when discussing scientific subjects among educated men and will thus offer a distinct set-back to the cause he supports.

Solution of the problem.—The solution of this problem has been discussed in details by Dr. Ukil and Col. Chatterjee and I do not like to repeat them here.

XXII. GROWTH STUDIES WITH SPECIAL REFERENCE TO NUTRITION AND PUBLIC HEALTH SURVEYS.

(Section of Medical and Veterinary Research, in co-operation with the Indian Statistical Conference.)

DR. J. B. GRANT, Calcutta, presided.

Prof. P. C. Mahalanobis gave a general summary of a joint paper with Mrs. Chameli Bose 'on age-specific family consumption index'. This evoked a keen discussion in which doctors and biochemists participated revealing admirably in this way the need for collaboration between nutrition workers and statisticians.

An important paper 'on the height, weight and chest measurements of schoolboys in Bombay' by Dr. J. N. Mehta, Dr. K. S. Mhaskar and Mr. L. S. Vaidyanathan was presented by Prof. Mahalanobis in the absence of the authors.

Mr. K. Raghavan Nair explained the computational methods used in a paper on the 'standard error of reproductive rate from sample surveys'.

Dr. P. V. Sukhatme, New Delhi, gave a summary of his joint paper with N. Sundar Rao on 'seasonal variation in the incidence of Filarial Lymphangitis'.

Mr. K. R. Nair then spoke on the paper on 'heights and weights of school children in Madras'.

This was followed by a discussion. Mr. S. Sen Gupta, Calcutta, presented a preliminary note on 'measurements of blood pressure in Calcutta'.

The Chairman then called upon Professor Mahalanobis to speak on the application of statistics to problems in public health. He was followed by Dr. G. Sankaran, Calcutta, who explained the difficulties and pitfalls in a routine use of statistical methods.

The Chairman, in his closing speech, emphasized the great value of statistical tools in public health and medical studies, and made an appeal for closer collaboration between the Public Health workers and the Statistical workers.

XXIII. DROUGHT RESISTANCE IN PLANTS.

(Section of Agriculture.)

MR. K. RAMIAH, Indore, presided.

1. PROF. P. PARIJA, Cuttack

Induced Drought Resistance by pre-germinal treatment.

Resistance by plants to drought must clearly be dependent on capacity to absorb water against resistance offered by soil moisture and to withhold water against loss by transpiration and finally to maintain life with reduced water content of the cell. This capacity is in general hereditary.

Recent work on vernalization has, however, shown how deficiencies in mature life can be remedied by pregerminal treatments. Pregerminal

treatment as regards drought resistance was undertaken in paddy. The results are encouraging and the work is being continued. It is too early yet to give a physiological explanation of this induced capacity for resistance to drought.

2. PROF. B. N. SINGH, Benares.

Physiology of Drought Resistance.

The problem of drought resistance in plants is one of considerable interest both from the fundamental and applied points of view; on the fundamental side it would give an insight into the morphological and physiological characteristics of an important class of plants in relation to their peculiar environment while the understanding of the underlying principles of drought resistance would be of immense value in the production of drought resistant strains and in studying crop ecology specially in dry farming regions.

The problem is discussed with particular reference to the following aspects:—

(i) Definition of drought depending upon the conditions of soil and atmosphere; causes of drought; ecological grouping of plants on the basis of their growth characteristics.
(ii) Water balance of drought resistant plants under varying conditions of moisture availability; susceptibility of plants to drought at various stages of their development.
(iii) Morphological and physiological characteristics of drought resistant plants, viz., root development, leaf structure, cell-size, and absorption, transpiration, photosynthesis and physico-chemical properties of plant sap with special reference to 'Bound-free' water relationship.

The explanation is offered that the basis of drought resistance in plants may be the capacity of the protoplasm to endure fluctuations in its imbibed water content without the loss of vital activity. The other anatomical and physiological peculiarities accompanying drought resistance may be secondary.

The bearing of drought resistance on the production of crops in dry regions and the production of ecological factors in agronomic practice is discussed.

3. MR. P. C. RAHEJA, Tarnab.

Physiological Basis of Selection for Drought Resistance.

Since the factors or a combination of factors that make for xeromorphism of a variety reside within the individual cells, the basis of selection for drought resistance should be the study of physiological characters of the plant. Experimental evidence on varieties of cotton and sugarcane has shown that such a basis can be employed for selection of drought resistant varieties. Transpiration and respiration experiments on cotton indicated that 'Quiescent state of Wilting', 'wherein forces of supply and demand of water in the cellular units tend to balance at par, can serve as one of the bases of selection for drought resistance. Furthermore, a very high coefficient of correlation between osmotic pressure of cell sap, a character of special importance in drought resistance, and electrical conductivity in wilting plants indicated that both are important attributes for selection of hardy varieties of crops.

Relative respiration rate of eight sugarcane varieties exhibited that drought resistant varieties had relatively lower respiratory quotient of roots, under identical conditions of growth, than the relatively less

drought resistant ones. This fact confirmed the observation that greater vertical penetration of roots of sugarcane varieties was indicative of their drought resistant nature. Hot weather respiration studies showed that with increasing drought the rate of foliar respiration remained constant for a longer period in drought resistant varieties than in others. Relative efficiency of water requirements and the rate of transpiration of varieties did not indicate any specific relationship to the drought resistant nature of varieties.

4. MR. I. M. RAO, MR. M. AFZAL *and* PROF. J. C. LUTHRA, Punjab.

Physiological aspect of Drought Resistance in Crop Plants—Bajra *and Wheat.*

A detailed study of drought resistance in crop plants is quite essential to Indian agriculture, as large areas in India depend mainly on the vagaries of Monsoon rainfall for crop growth and they are characterized by severe drought conditions of different durations. The physiological aspect of the problem of drought resistance has been under study for the last five years at the Punjab Dry Farming Research Station.

Two types of *bajra* (*Penisetum typhoideum*), local and A1/3, and two of the wheats, 9D and 8A, were selected for these studies. Comparative studies were made on the root-systems, growths in different seasons, morphological characters, stomata, leaf-area, leaf-water-content, osmotic pressure of leaf-sap, rate of transpiration, water requirement, photo-synthetic activity, and resistance to soil and climatic drought under controlled conditions. *Bajra* local and wheat 9D are found to be comparatively better suited to dry areas than *bajra* A1/3 and wheat 8A.

A large number of main roots penetrating to deeper layers, narrow and coriaceous leaves with less total leaf-area, thin stems, shorter plants, rapid early growth of the shoot, early tillering, a larger number of tillers, early earing, a longer period over which ears continue to appear and mature, a larger number of mature ears (though small) instead of single big ear, a lower rate of transpiration during the maximum transpiring period, less intense fluctuations in transpiration due to drought, a lower total amount of water transpired, a higher photo-synthetic activity during drought periods, a higher osmotic pressure of leaf-sap, a consistently lower leaf-water-content, a higher frequency for stomata and epidermal cells and a smaller size for the same, a higher stomatal linear constant and stomatal index, and capacity to recover better after soil drought are all found to be characteristic of plants which can grow successfully in dry farming areas, because most of them enable the plants to escape, endure, or resist drought. Most often, the strains that are successful under these conditions are drought-enduring or drought-escaping, though they are often called drought-resistant.

The results are discussed in detail and the importance of a proper selection of strains for dry areas from a study of the above characters is pointed out.

5. MR. K. KUMAR, Benares.

Drought resistance is a question of 'bound water' and 'free water', the resistant varieties possessing more of the former. The content of hydrophilic colloids in the resistant varieties is also higher than in the non-resistant varieties.

6. DR. B. SANJIVA RAO, Bangalore.

True drought resistance is associated with the existence of hydrophilic colloids in the plant sap. Work was undertaken at the Central College, Bangalore, at the instance of the Department of Agriculture,

Mysore, on drought resistance in *ragi* (*Eleusine coracana*) and it has shown that there is correlation between drought resistance and the hydrophilic contents of the plant sap. There is necessity for close co-operation between colloid chemists and plant physiologists in the study of drought resistance.

7. MR. N. K. ANANTHA RAO, Benares.

Plants may escape drought by maturing before drought conditions set in or plants might endure drought by economizing their water requirements. It is possible to classify plants ecologically as drought escaping, drought evading, drought enduring and drought resistant. The question of 'bound water' is important in explaining real drought resistance.

8. DR. V. G. PANSE, Indore.

The question whether the induced drought resistance mentioned by Prof. Parija is inherited is worth studying with reference to both the aspects, viz., germination under adverse conditions and drought resistance during later growth, by using some suitable index such as the amount of water in the plant. Progenies of treated and control seed may be thus compared.

9. MR. GHIASUDDIN AHMAD, Lyallpur.

Physiology of Drought Resistance.

Drought resistance in plants in many cases may mean losing less water in the process of transpiration. Transpiration takes place through very minute capillaries and if the size of these capillaries is small, transpiration will be less. It may be possible to evolve certain types or races of plants by breeding which will resist transpiration loss by having smaller capillaries and this might mean permanent improvement. At present, the behaviour of the plant under drought conditions is perhaps the only criterion to go by with regard to the size of the capillaries.

10. RAO BAHADUR T. S. VENKATRAMAN, Coimbatore.

Breeding for Drought Resistance—Sugarcane.

The two main classes or groups of the sugarcanes of the world—viz. the thick 'noble' types and the thinner sub-tropical types—differ from each other in many important field characters and relative drought resistance is one such.

In sugarcanes both the depth of roots as well as the extent of leaf areas have shown correlations with drought resistance. The rolling of the lamina halves—either inwards or outwards—has been noticed to be a probable adaptation against temporarily prevalent drought conditions.

The easiest and most direct method of testing new productions against any set of drought conditions is to actually grow them under the conditions. The resistance needed is often associated with other characteristics in the environment which it is not possible to reproduce at a central research station with much confidence. In the Indian sugarcane work, there have been indications that adaptations of the plant, like the ones now under discussion, show the greatest development only under the actual conditions. Co.281 has been found to resist waterlogging, first in Florida and subsequently in India, and its roots show definite air spaces in the ground tissue when this cane is grown under such conditions. These air spaces do not develop to the same extent when this cane is grown in garden land.

The next best is to try and simulate in the fields at the central research station the conditions against which the new productions are ultimately intended to be grown through sparser irrigations or lesser dosages of water in the case of irrigated crops.

While laboratory studies on correlations between drought resistance and various morphological or physiological characters is desirable, such work should not be allowed to take the place of trials under actual field conditions. At best laboratory studies could only supplement or explain field results. It is only after considerable accumulation of such data and their satisfactory tallying with out-station field results, that it will be possible to prophesy from laboratory studies the probable drought resistance of particular types

Besides the adaptations already mentioned, another such in the sugarcane is a thrifty above-ground-growth during the stress summer periods with a fully developed underground system to enable the plant to burst into full activity when the drought conditions disappear in the course of the seasons.

The drought resistant canes so far obtained at Coimbatore—and these are quite a number—have been the result of hybridization with types which have been known to thrive under such conditions, some of these being wild *Saccharum* types.

For the breeding of types to suit particular regions, where drought prevails, the breeder should first secure an adequate knowledge of the environmental conditions all through the life-cycle of his crop. It occasionally happens that what is really needed is not a general kind of drought resistance in the new productions but resistance to drought conditions at one or more states in the life-cycle of the plant. A locality which is liable to drought at an early stage of the crop may, for instance, be liable to waterlogging at about harvest time. In such cases drought resistance alone would not meet the situation. The type needed would be one which would resist drought in the earlier stages and waterlogging in the final stages of its growth. Wild or related species which grow freely and easily under the conditions are likely to prove of value in the breeding of the desired types. The results obtained from sugarcane breeding in India testify to the utility of such crossing.

Briefly stated drought resistant sugarcanes for India were obtained by employing as parents species of *Saccharum* or other genera (like *Sorghum halepense*) known to possess drought resistant characteristics. Their selection has been by actually growing them under the conditions. The wild *Saccharum* employed happens to stand both drought and waterlogging which is fortunate and certain of the resultant hybrids have displayed both these characters, besides increased yields.

11. DR. B. P. PAL, New Delhi.

Breeding for drought resistance.

One of the major problems with which the plant breeder in India is faced is the creation of crop varieties which besides possessing other desirable qualities are capable of yielding a good crop in spite of the occurrence of drought during the growing period. Drought may be atmospheric or edaphic or a combination of both. A plant is considered to be drought resistant if it is able by some internal means, induced or inherent in its constitution, to survive a period of drought and to produce almost a normal crop. In India drought is generally experienced towards the later part of the growing season of the *rabi* crops and in the rainless intervals during the rainy season of the *kharif* crops.

In the case of the latter the aim of the breeder should be to breed varieties possessing an extensive and effective root system, a high suction pressure of the cells and a well-developed vascular system for the efficient and rapid conduction of water from the roots to the transpiring organs;

it would probably not be desirable to aim at varieties possessing devices for checking transpiration, such as thick cuticle, sunken stomata, covering of hairs, etc., as photo-synthetic activity would be depressed. In the case of the *rabi* crops which have to pass through a different set of environmental conditions, the position is rather different, and the breeder has to evolve varieties which are capable of withstanding prolonged wilting towards the later part of their period of growth without injury or lessening of yield.

Although the problem of drought resistance has been studied in recent years there are hardly any available instances of drought resistant varieties having been 'bred to order' as in the case of some of the other characters which have received attention at the hands of plant breeders. The reason for this is the difficulty in resolving the factors which together determine drought resistance, and the further difficulty of devising critical tests for drought resistance in the earlier stages of breeding work when very small populations have to be handled.

12. MR. M. ALAM *and* MR. A. B. SARAN, Sabour.

Breeding for Drought Resistance—Rice.

The problem of drought resistance is rather difficult to solve for a crop like paddy that ordinarily grows in standing water. We, however, come across large areas all over the province that could grow nothing but paddy and at the same time they are not capable of retaining sufficient moisture for the normal crop. Apart from this aspect of the question, we have also to face the problem of failure of rains in certain years and in different tracts, when only drought resistant varieties could successfully be grown.

In order to tackle all these aspects of the problem, a beginning was made by selecting desirable strains from out of a large number of samples collected from all over the province and grown under artificial drought conditions, i.e., after the transplanted crop had once established itself, no artificial irrigation was given and steps were taken even to drain out any rain water that would accumulate in the plot. Detailed growth studies and survival percentages were determined each year and necessary selections, based on these studies, were made. Preliminary selections thus made were further tested for their endurance to permanent wilting, on which great stress has been laid by Russian workers like Maximov and others, who regard this as an index of the capacity of the protoplasm to endure considerable fluctuations in its degree of swelling, without loss of vital activity. These studies, along with yield determinations, have resulted in obtaining 12 outstanding drought resistant selections, out of which six are of early duration and the others of medium duration.

Water requirements of those outstanding selections have also been determined for three consecutive years and they further establish their suitability for drought resistance. Finally, the question of breeding in relation to certain anatomical and physiological characteristics is discussed and the success of the present attempt indicated.

13. MR. BHOLA NATH, Indore.

It is suggested that the genetic basis of drought resistance should be understood. Dr. Harland found it impossible to transfer drought resistance from the wild xerophytic cotton (*G. tomentosum*) to the cultivated cotton (*G. barbadense*). He explained the failure on the assumption of multiple factors conferring drought resistance. In the success achieved by Rao Bahadur Venkatraman in transferring the character from a wild cane to a cultivated one, it is possible very few factors were involved. Moreover, sugarcane being propagated vegetatively, the question of later

disintegration does not come in. With regard to Prof. Parija's experiment, it is unlikely that the induced drought resistance will be transmitted to the progeny. It should, however, provide the agriculturist with a simple process of seed treatment to induce drought resistance in the crop.

14. DR. V. K. BADAMI, Cuttack.

The question of breeding for drought resistance is very complicated, as for instance, in rice under the conditions prevailing in Orissa, the same plant has to satisfy different conditions at different stages of growth such as resisting drought, resisting floods and resisting salinity. The breeder cannot always rely upon some of his productions accidentally proving suitable to certain conditions. I agree with Rao Bahadur Venkatraman that breeding for requisite qualities must be done under the particular field conditions and there is great scope for the chemists and physiologists to co-operate with the breeder in this work.

15. MR. S. SAMPATH, Benares.

He enquired whether it is possible to breed crop types which are high yielders in good years when water supply is abundant and drought resistant in years when water supply is deficient. Prof. Boshi Sen, Almora, replied that it would be possible if we knew how to modify the permeability of the cells of the embryo.

16. DR. P. H. CARPENTER, Tocklai.

Drought resistant character may be related to changes in other characters. Rao Bahadur Venkatraman pointed out two classes of sugarcanes, the tropical which is a juicy rich cane, and the cane indigenous to N. India which is small, hardy, drought resistant and of poor quality. There is some reason to think that drought resisting varieties may have different quality characters to other varieties and in some cases will have poorer quality. I mention this as it links this discussion with the one we are to have a few days later on quality in crops. Another case of interest is that of flax with the growing of which we have been experimenting this cold weather. It is noticeable that the plants growing on the soils treated with calcium cyanamide are greener and more luxuriant looking, and seem to be resisting droughty conditions better than those plants either not manured or that have received acid manures. It is very desirable that much more work should be done by plant physiologists possibly in collaboration with colloid chemists to find out what are the conditions within the individual cell that causes a plant to be resistant or susceptible to drought.

17. MR. A. K. YAGNA NARAYANA IYER, Bangalore.

Drought Resistance and Cultural Practices.

The subject of drought resistance in crops is of special interest in India as the bulk of the area is dry farmed depending solely on rainfall and only a comparatively small area is protected by irrigation. The vagaries of the rainfall are only too well known and Indian agriculture is indeed one never-ending fight against such vagaries and the task of the farmer has been to dodge the drought as best as he can. Through experience and practical wisdom a variety of agricultural practices has been devised all of which are within limits quite efficient and may well form the starting points for further study and improvement.

The object of these practices is attained by (1) selection of crops suited to this condition, and (2) the adoption of cultural methods which will enable the crops to resist the drought. The kind of dry crops evolved

and now cultivated as purely rain-fed crops, may be said to be exceptionally efficient. Earlier investigations in Mysore had shown that crops like gram (*Cicer areitinum*), *ragi* (*Eleusine coracana*) and the millet (*Paspalum scrobiculatum*) can thrive under even very low moisture contents of the soil in the first two feet of the soil. In the selection of drought resistant crops, the scope would therefore appear very small though the possibilities of the existence of still hardier varieties cannot be excluded nor that of introducing by breeding morphological characters favouring drought resistance in the existing varieties.

The peculiarity of dry farmed grains is their extreme earliness, some of the millets maturing in 60 to 90 days, though their yields are comparatively low. With the exception of Jowar, they are all thin leaved, they are all shallow rooted but with a profuse root system. Apparently the drought resisting capacity is in direct proportion to this kind of root development. A study of the peculiarities of the root system in all its aspects is likely to lead to promising results and deserves to be undertaken. It may be pointed out that even in an irrigated crop like sugarcane, the variety *cheni* which is reported to be drought resistant has, in contrast to other varieties, a larger root development.

The more important and practical aspect of drought resistance is in relation to cultural practices which have for their object (1) to receive as large a portion of the rain into the soil by producing suitable conditions for the same, and (2) to conserve as much of it for the benefit of the crop by reducing the losses. All the cultivation practices in dry farmed areas refer to the above. The Mysore experiments had shown that a surface soil mulch did exert a protective effect and that soil moisture could rise from a depth of six feet below the surface. Apart from the soil moisture studies, field experiments with *ragi* had shown the advantage of ploughing up the field immediately after harvest and this practice has been one of the important recommendations by the Department. Suitable implements were also devised and suggested for such ploughing. Among the operations to reduce losses of moisture from the soil, may be mentioned sowing the crops by drills to facilitate interculturing. The benefit due to the mulch, apart from what interculturing does in removing weeds and thinning the crops, is not very clear unless it be that even very small differences in moisture contents lead to marked differences in the growth of the crops. To what extent surface cultivation can reduce the need for irrigation in the case of irrigated crops, is also a point for investigation. The question of soil moisture requires more extensive studies.

The problem of drought resistance in crops has been raised in the past in India more in connection with pasture grasses than with ordinary field crops. Many grasses were imported from abroad in the hope they would stand the Indian drought conditions better, but the general experience has been that all these introduced grasses are less drought resistant than the indigenous grasses. The only grass that has been found to be of some value for Mysore conditions, is the Napier grass (*Penesetum purpureum*).

The study of drought resistance should comprise work firstly on the characters which confer this ability to the plants and secondly on the movements of soil moisture and methods of moisture conservation. Scope for extensive work lies however on the practical side with a view to enable farmers to take to methods of dry farming which are already known to be beneficial.

18. RAI SAHIB KALIDAS SAWHNEY, Parbhani-Dn.

Water plays a dominant part in the life of plants and it is *the* most important single factor determining the successful growing of field crops. The varying vegetation of different habitats and the varieties of crops that can be grown in a given locality are determined largely by it. In

nature marked structural reactions are exhibited by plants in response to conditions of water supply prevailing in the different environments. Under conditions of water stress in arid or semi-arid regions of the world, plants, as a rule, possess extensive tap roots that reach great depths and have but few lateral roots. They are also characterized by small, hairy, heavily cutinized or waxy, thick leaves with sunken stomata and multi-layered pallisade tissue. These special features of xerophytic plants are either organs for drawing water from great depths and storing it, or are protective structures against excessive transpiration. In the case of field crops plants receive assistance of various kinds from man to absorb moisture from great depths, withstand excessive loss of water, and be able to grow and reproduce under conditions of drought. In fact, the fundamental object of the cultural practices used in 'dry farming' is to enable the plants to grow successfully in environments characterized by a marked deficiency of moisture. The following paragraphs briefly enumerate some of the important cultural methods adopted and the nature of the aid that they are intended to render to the plants and crops concerned.

(1) *Soil-treatment which favours ready penetration of water and enables a very large proportion of the annual precipitation to be stored in the soil :—*

Practices to keep the top soil porous and receptive or to reduce the rapid run off of rain water fall in this category. Repeated ploughing in the dry season before the rains, the levelling of soil having a steep gradient, ploughing across the slope, embanking of fields and dividing them into small units by inter-plot *bunds*, addition of organic matter and fallowing of soil are means to these ends.

(2) *Practices that facilitate a full and free development of plant roots :—*

Deep ploughing before sowing and deep interculture of the standing crop induce the roots to penetrate to great depths.

(3) *Cultivation that prevents the direct evaporation of moisture from the soil and reduces transpiration :—*

Ploughing immediately after harvest, cultivation after every rain and increasing humus in the soil reduce direct evaporation and tend to conserve moisture until it is needed by the plants. Similarly, a wide spacing of plants and the frequent weeding and mulching of soil during the growing season of the crop are believed to retard both surface evaporation and transpiration.

(4) *Practices that enable plants to evade drought :—*

By adjusting sowing date and planting quick maturing varieties, plants may be enabled to complete their growth before scarcity of water becoms really serious.

For the selection of correct aids to drought resistance, a full knowledge of the prevailing climatic and soil conditions along with that of the response of the plants concerned to the given environment is necessary. Finally, it may be mentioned that scientific plant-breeding is often successful in producing varieties of crops and plants that inherently need small quantities of water for their growth and maturation, or which due to structural peculiarities are well fitted to grow under conditions of water scarcity.

19. MR. MASON VAUGH, Allahabad.

Drought Resistance and Cultural Practices.

The object of all agricultural improvements is ultimately increased production. It is well to do all we can to improve the plants with which

we work. We should also improve growing conditions for the plant and up to now very inadequate attention has been given to this phase. (1) The growing season can be extended by early planting which becomes possible with pre-rainy season preparation. (2) The water stored in the soil can be increased by extending the absorbing season and by improving absorbing conditions during the rainy season. (3) The utilization of the available water can be improved by improving the water holding ability by modifying the soil, particularly with regard to its organic matter contents. All the above objectives are primarily to be reached by a better application of engineering to agriculture, by better use of more suitable implements and by better utilization of power. An attack on the problem may—probably will—give larger and quicker results than plant breeding. This should be given more attention generally by agricultural workers and by the Science Congress.

XXIV. QUALITY IN CROPS.

(Sections of Agriculture, Chemistry, and Medical and Veterinary Research.)

MR. P. M. KHAREGAT, New Delhi, presided.

1. RAO BAHADUR B. VISWA NATH, New Delhi.

Quality in Crops.

The problem of crop production has assumed a new phase in recent years. In addition to the demand for increase in production per acre, the new one is for quality.

A significant development which concerns the agriculturist is in regard to certain specific qualities and standards demanded by trade and industry which employ agricultural produce in several industries. As examples may be cited milling and baking qualities in wheat, malting quality in barley, qualities for cigar and cigarette and for chewing purposes in tobacco, and quality for *gur* and sugar manufacture in sugarcane.

It is being recognized that large variations in the proximate and ultimate constituents of the same variety of plants are indications of soil conditions and fertilizer treatment, and that plants have wide powers of accommodation although they can grow in a manner that does not show appreciable variation in appearance and gross composition. Evidence is accumulating that soil conditions and soil treatment may even modify the make up of the plant and its constituents and the degree of their usefulness. Varieties of wheat grown under different conditions showed differences in their dough qualities and loaf size of bread; again, heavy applications of nitrogenous manures increased the nitrogen content of wheat, but the increased protein content did not necessarily improve the baking quality, which appeared to vary with the season. Fertilizer treatment and environmental conditions such as soil and climate, influence the malting quality of barley. Nitrogen content varied directly with diastase value and inversely with the carbohydrate content; the extract and amount of nitrogen are influenced by fertilizer treatment, soil conditions and season. Similar observations have been recorded with jowar malts. Under certain circumstances nitrogenous fertilizers applied to sugarcane are known to give soft jaggeries with poor keeping qualities.

The differential effects of different potash salts on the quality of tobacco and potato are well known.

A more recent and important development of world-wide interest, is in regard to quality in food crops. The question of quality in crops from the national diet, health and hygiene point of view has begun to be seriously considered. It was formerly believed that proteins, carbohydrates, fat, and water were all that were necessary for a complete diet. It was later realized that certain mineral salts were also necessary. Subsequent experience revealed the importance and necessity for vitamins without which animals cannot grow and keep healthy. With the advance in the knowledge of the chemical nature of the various substances used as food it became apparent that a mere study of the total protein requirement presents but a feeble view of the complexity of the processes of digestion and assimilation and of certain minute requirements and nice adjustments involved. All proteins have not been found to be of equal biological value—they varied with the nature of the amino-acids of the proteins. The knowledge that amino-acids are building stones for the protein molecule and that these constituents cannot be synthesized in the animal body but have to be given in a preformed state, either as plant protein or as the flesh protein of animals that eat plants led to further enquiry which showed that all amino-acids are not of the same nutritive value and that all foods do not contain all the necessary amino-acids.

Recent developments in soil and plant research provide evidence that the products of plant metabolism that nourish and sustain animals and human beings can be influenced by soil conditions and systems of manuring. Questions of theoretical interest apart, like the nature of action of manures and fertilizers first on plant metabolism and, through the plant, on the anabolic and katabolic processes in the animal, it appears that nutritional factors for animals are associated with nutritional factors for plants and that the biological efficiency may vary with the conditions of growth. These developments and their implications in agricultural production and national nutrition and health are discussed.

2. MR. A K. YAGNA NARAYANA IYER, Bangalore.

Some general considerations of quality in Crops.

The subject of quality in crops may be said to comprise two important questions. The first is a determination of the nature and composition of the substance or set of substances which gives a product its special value and generally decides its market price as compared with other grades of the same product; parenthetically one has to qualify this price deciding factor to some extent because in a number of cases the market value which is fixed by public taste is not always in accordance with the intrinsic merit of the product as indicated by its content of nutritive elements; the commonest example of this statement is, of course, rice. The second is a determination of the factors which govern or influence the content of this quality-giving substance in the particular product and the extent to which such factors are controllable in practice. From the practical point of view this second is the more important, for if these factors cannot be controlled then the question is only one of purely scientific interest.

As regards the first question, viz., the nature of the substance which decides the quality of a product, the matter is comparatively simple in most cases; thus the content of oil in oil-seeds, starch in potatoes, sugar in sugarcane, the colouring matter in dye-yielding plants, proteins in grain and pulses, the active principles in the innumerable medicinal plants, the fixed and volatile oils in flowers or perfume yielding plants and trees, these are the deciding factors in assessing the value of the product in its particular class as compared with others in the same class, and

they are ranked high or low according as they are rich or poor in these substances. There are other products, however, in which the quality-giving factor is indefinite and obscure and in this class come those products whose quality is judged mostly by taste or flavour. Coffee and tea are outstanding examples as likewise are butter and ghee and the numerous fruits and vegetables. The data upon which the epicure's tongue can grade and classify these are not yet sufficiently well understood to be capable of chemical definition and measurement. In recent years the content of accessory food factors or vitamins, growth-promoting hormones and such substances are also entering into the question of quality and though their chemical nature and estimation are still a matter of study, biological methods of assay have rendered their practical consideration both possible and important.

Hardly any work of a scientific nature has so far been done upon what really constitutes quality in crops of this latter class. The first and perhaps the only work attempted on this subject is that on the quality of coffee which was carried out by the Mysore Department of Agriculture during the years 1906 and 1907. In this work an attempt was made to find out what constituent of the coffee, both organic and mineral, and what physical characteristic were an index of quality as fixed by the market price, apart of course from points like cleanliness, colour and the like. For this purpose, over fifty samples of coffee beans representing all the distinctive coffee tracts of the world, all valued and classified by London brokers, were examined. The result of this prolonged investigation was however disappointing, because none of the chemical constituents were found to run parallel with the prices. The specific gravity was however the one factor which behaved differently and was found to be sufficiently close to the prices as to be taken as an index of the quality. It will be noticed that as far as the quality-giving factor in the composition of the bean was concerned the work gave no information whatsoever. The work unfortunately was given up at this stage but has recently been taken up for further investigation under a much expanded scheme. The results will have to be awaited. In regard to the subject of quality in other crops the field may be said to lie completely unexplored. A beginning has however been made with rice and some other food grains, thanks to the nutrition studies taken up in recent years about which we may hear a good deal in the course of this discussion.

Coming now to the second question, viz., the factors which influence the composition or quality of products, these factors are firstly of the kind that are not under the control of man, such as geographical situation, altitude, aspect, rainfall, humidity and so on. Coffee differs a great deal in quality according as it is grown under this variety of conditions; tea is distinctly classified into high, medium and low elevation quality which correspond to great variations in flavour and price. The perfume of flowers grown in warmer climates is generally stronger than when they are grown in milder climates. The numerous delicate shades of colour characteristic of differently named varieties of roses in Europe often disappear under warmer skies where they tend to run down into a dull uniformity. In respect of fruits and their delicate flavour, taste, colour and size, climatic conditions lead to marked changes, and even in the same locality seasons influence the taste; the Coorg orange of the monsoon season is much less sweet than the fruits of the summer. The active principles of many medicinal plants vary in quantity according as they are grown under conditions favouring luxuriant growth or under conditions where they have to struggle hard for existence. Instances of this kind can be multiplied. Although from a practical standpoint this aspect of the question is not of much importance inasmuch as these conditions are beyond human control, still their study must afford valuable information for guidance as to the conditions most conducive to quality under which alone they may therefore be grown with advantage and some of which may be capable of being reproduced to some extent artificially.

The second set of factors which may influence quality are those environmental factors which are capable of being controlled and it is a study of these factors that will lead to important practical results. The foremost of these factors are of course manures and the constituent elements of soils. What effect have those constituents, both organic and mineral and especially the so-called plant foods, on the quality or composition of the crop? Can we alter the content of starch, oil, protein or colouring matters, tannins, alkaloids, etc., in the crop by suitable forms of manuring? Can we increase or reduce the proportion of the mineral ingredients in the product by the same means? Though innumerable manurial experiments have and are being conducted it must be admitted that few afford any reliable answer to these questions, beyond what has been known and believed for a very long time. This can be summarized very briefly. Nitrogen increases the vegetative growth, phosphoric acid hastens maturity and favours grain formation rather than leaf growth, potash favours the formation of starches and sugars; highly nitrogenous manures lead to coarseness and often make plants more susceptible to disease. Nitrogen also increases the protein content of grains if applied at particular stages in the growth of the plant. It can also increase the content of nicotine in tobacco. Sugarcane juice can take up alkaline salts from alkaline soils and yield a juice with a high ash content which reduces the recovery of sugar by preventing normal crystallization. Even acid radicals have different effects, chlorides have a deleterious effect on the burning quality of tobacco in contrast with sulphates and nitrates. The colour of the Hydrangea flower can be changed from pink to blue by changing the reaction of the soil. Sulphur, magnesium, selenium, titanium, copper, manganese, zinc and boron, can all influence the quality of certain products, even when present in small quantities like catalysts. The seeds of crops are generally constant in their mineral composition, while the vegetative parts, notably the grasses, are subject to great variation in this respect depending on soil composition or manuring. Though this much can be gathered from experiments so far, manurial experiments designed to yield definite answers to the above queries are rare. The whole range of manurial experiments may be said without exaggeration to have related almost exclusively to measuring the effect of manures in terms of the increase in the *quantity* of the produce. The weighbridge has indeed been the sole judge of the way in which crops respond to manures. One result of these experiments in India is the belief that it is not necessary to manure with potash or phosphoric acid, nitrogen alone being sufficient and the response from the former being either too little or none at all. As it has not been usual so far to investigate the composition of the manured product also in these experiments, data are not available to warrant the conclusion that these two ingredients have gone without effect or that the nitrogen has had no effect other than increasing the quantity of the produce. It is at least permissible to suppose from the information summarized above that these ingredients must have influenced the composition or quality of the product and that in shutting our eyes to this possible effect we are probably sacrificing quality for quantity. The scope and the need for widening the sphere of manurial experiments to include a determination not only of the chemical composition of the product but also of its vitamin content, where necessary, are strongly to be emphasized.

While the above observations relate to the effect of the so-called plant food elements, it is beginning to be claimed that quality is capable of being influenced by organic manures, i.e., by organic matter alone as distinguished from the plant food elements including nitrogen. So far the function of organic matter of this kind (that is, devoid of mineral elements and nitrogen) is considered to be largely indirect, such as improving the physical condition of the soil, increasing the availability of the mineral ingredients by the solvent action of the weak acids of decomposition, and as serving as the source of energy to the free-living bacteria in

the soil—all of which in their sum total is tantamount to increasing the quantity of plant food at the disposal of the crop. It is not known if and in what way this kind of organic matter can or does change the composition of the crop manured. Another aspect of the question relates to the effect of organic matter derived from the excreta of animals as distinct from organic manure derived from other sources. That farmyard manure greatly increases the yield of crops is a fact of universal experience from the dawn of agriculture; but it is true also that similar increase of yield can be brought about by the use of appropriate quantities of mineral manures and of organic matter other than animal excreta. The new claim however is that the effect of the farmyard manure shows itself in improved quality in the grain as distinguished from the quantity yielded, and that enhanced quality is demonstrable by methods of biological estimation. Rao Bahadur Visvanath's work on this subject is very interesting and if confirmed by other workers will have much economic importance. It has been sought to base this result on a sort of philosophic concept, the idea being that it is the only way in which nature's cycle *soil-crop-animal* can be maintained unbroken. The view may be also said to gain strength from the fact that among the many root-growth promoting substances like the acids containing the indole group now being studied in the Boyce Thompson Institute, the compound Skatol takes a high place and that it is a compound also present in the excreta of animals. It must however be mentioned that the wheat from the famous farmyard manured plots in Rothamstead have been reported not to show superiority in quality over other wheat, in the face of which the above considerations cannot be deemed adequate to support the new view. It would thus appear that the matter is one for further experiment and cannot at this stage be taken as proved.

While stressing the fact that the whole subject demands a great deal of experimental work, the need for which will be amply clear from the above survey, I shall conclude by stating that when it comes to a practical application of the results we shall have to look to the methods of plant breeding as the most potent instrument to bring about enhanced quality or increased proportion of the product for which a particular crop may be economically valuable. Well-known work along these lines are the improvement of the sugar beet, the evolution of high-protein, low-protein, high-oil, low-oil and other distinct types of maize, of new varieties of high-yielding sugarcanes, of cinchona with a very high alkaloid content and of rubber with a high latex producing capacity—all of which demonstrate the extent to which improvement can be brought about by this method.

3. DR. W. R. AYKROYD, COONOOR.

Nutritive Aspects of Quality in Crops.

The speaker considers the question of quality from the standpoint of nutrition. The commercial quality of a food product often depends on attributes which are independent of nutritive value, such as flavour, appearance and sometimes the obscure preference of the consumer for certain particular varieties. The problem for discussion can be posed as follows: Does the nutritive value of different samples of the same food vary as the result of differences in botanical strain and conditions of cultivation? And if such variations exist, what is their importance in human nutrition?

The degree and nature of variation which could be produced by selection and improvement in soil conditions must be carefully investigated. First, the degree of variation in any particular constituent must be considered in relation to human requirements of that constituent. Secondly, an increase in the content of some single constituent, such as protein or phosphorus, might not in itself be of any striking value if the

amount of other equally important constituents present remained unaffected. Thirdly, variation in chemical composition would clearly be of greater importance in the case of a food which formed the bulk of the diet than in the case of a food taken in smaller quantities.

Probably only biological tests could provide conclusive evidence of the superiority or otherwise in nutritive value of new varieties produced by selection or of foods grown under certain chosen conditions of cultivation. Such tests are not easy to carry out. The speaker is sceptical about recent claims that foods grown on land treated with organic manure are in some indefinable way 'healthier' than food produced on land treated with artificial manures.

The vitamin B_1 content of a series of different strains of rice and *ragi* (*Eleusine coracana*) has been studied in the Laboratories. Variation has been observed, but all unmilled samples contain enough vitamin B_1 to prevent beri-beri. In the case of rice, the effect of milling and washing on vitamin B_1 content greatly outweighs any importance in initial variations in composition. Little variation is found in the vitamin B_1 and nicotinic acid content of samples of the same strain of wheat grown under different manurial conditions. These observations are in line with those of other workers in England and Germany. Analyses of the calcium and phosphorus content of foods grown in the Kangra Valley, Punjab, and in South India give strikingly uniform values. It is, however, difficult to draw any general conclusions as to variation in calcium and phosphorus content from these limited investigations. Unquestionably the phosphorus content of crops could be influenced by superphosphate manuring.

In conclusion, the speaker points out that Indian diets can be improved by greater diversification. The cereals which form the bulk of the diet must be supplemented by greater quantities of pulses, vegetables, milk and other foods. In his opinion, this is the policy to follow in trying to raise standards of nutrition. He does not think that a great deal would be achieved by attempts to bring about improvement in the nutritive quality of cereals or other staple foods, and upholders of the opposite view have not so far produced convincing evidence. But no final judgment on the questions at issue can be reached until they have been more exhaustively studied from different angles.

4. Dr. B. C. Guha, Calcutta.

Although the different manurial treatments might produce relatively small differences in the protein, mineral and vitamin contents of cereals and pulses, they might mean a good deal of quantitative difference so far as the nutrition of the Indian people is concerned, since the cereals and pulses form the bulk of their daily diet. As, however, there are discrepancies in the results obtained in different laboratories regarding the influence of manures on nutritive value of crops, it is suggested that experiments in the line should be carried out under controlled conditions in different laboratories in India, financed, if necessary by the Imperial Council of Agricultural Research.

5. Dr. K. V. Giri, Waltair.

Rather than attempting to improve quality in food crops by manuring, we should explore more fully the possibilities of growing more nutritious foods even at the expense of quality. Our main need is for cheap sources of vitamins and minerals, especially calcium. The cereal *ragi* is particularly rich in this respect and has in fact a calcium : phosphorus ratio very much the same as in milk. The production and use of this cereal in greater amounts than at present are, therefore, to be encouraged.

6. DR. A. SREENIVASAN, Indore.

It is contended that with rice, the effects of milling and washing greatly outweigh in importance any initial variation in composition and that it is more feasible to raise the nutritive value of rice by preventing these losses during milling and preparation than by attempting to produce, by selection or by manuring, varieties which are rich in nutritional ingredients. But, it is not always easy to get over an established habit and a rice with an initially higher content of nutritive elements will naturally retain more of these principles even after milling and washing. Further, it will be doubly beneficial if, in addition to preventing the losses during milling and preparation, it is possible to use a variety enriched in composition. Variations in chemical composition will clearly be of importance in the case of a food article like rice which forms such a large proportion of the rice-eater's diet.

7. MR. B. AHMAD, Calcutta.

Nutrition and quality in Crops.

The constituents of food essential for normal nutrition are proteins, fats, carbohydrates, various minerals and vitamins. These constituents vary both qualitatively and quantitatively in our common food materials both of vegetable and animal origin. Animals, however, can maintain in their tissues, e.g., milk, eggs, muscle, a much greater constancy of composition than plants in spite of wide variations and inadequacies of the essential constituents in their dietaries. On the other hand, plant foods vary very widely in composition and in their content of essential food constituents. Since man and animals depend ultimately upon plants for food, and since vegetarian foods constitute by far the larger bulk of our daily diet, the subject is of moment. From the nutrition point of view it is this variation in food constituents that governs quality in crops. Food crops containing these factors in optimum proportion and higher concentration are of greater nutritive value.

Various factors may determine the composition of plants. Some of them are (i) composition of soil, (ii) species and strain of the plant, (iii) climate and weather. The composition of the soil determines largely the mineral composition of food plants. The variations in phosphorus, calcium and magnesium contents may be as much as twenty-five times the difference between the minimum and maximum values. In fact there are many areas in the world where the soil is low in phosphorus, thereby affecting both plant and animal life. Areas similarly deficient in cobalt, iodine or other minerals are also known and are definite factors in the human health problem.

More important than the concentration of the minerals is the relative proportion in which they occur in any plant. Under different conditions, calcium and phosphorus contents often vary in opposite directions leading to adverse ratios which result in poor retention of both the minerals by man and animals. These extreme ratios will also result in excessive excretion of magnesium tending to cause a magnesium deficiency.

Different strains of the same plant, even when grown on the same soil and under similar conditions, may contain different amounts of any particular constituent. Thus, it is well known to agriculturists that in sugarcane, the genetic factor is the most important and most of the sugarcane research of to-day aims at producing a strain that will yield the highest disaccharide content. Different varieties of wheat grown under identical conditions are known to differ significantly not only in their protein contents but also in calcium, phosphorus, magnesium, potassium, iron and sulphur. The vitamin content varies still more widely in different strains. The vitamin C content of apples for example

may vary from 1·6–16% in different varieties. In different varieties of mangoes available in Calcutta markets vitamin C is found to vary from 2–400%. This is true of most other vegetables and fruits. For vitamin content, not only the nature of the soils, but also seasons, climate, manuring and degree of maturity are contributing factors.

The influence of climate on the degree of unsaturation of the oil produced by different plant seeds is also well known. An oil seed grown in a tropical climate gives an oil with a higher degree of saturation than when grown in a temperate climate. This fact may be of importance from the point of view of the nutritive value of the oil now that we know that certain unsaturated fatty acids are essential for normal nutrition.

These are a few instances to show how crops may vary enormously in their nutritive value under different conditions. An intensive study of the contributing conditions of soil, climate, seasons, manures, genetic strains, etc., would help us to produce food crops of high nutritive and economic value.

It is also necessary to devote more attention to the improvement, by the use of proper supplements, of the existing dietaries in different parts of the country. The pulse soya bean which has a protein content of about 40% is a particularly rich food, but unfortunately, people have not taken to it kindly.

Finally, there is need for collaboration between the agricultural and nutrition research laboratories in order that the two together may aim at improving the quality of food crops. There is, at present, a liaison officer, under the Indian Research Fund Association for the co-ordination of nutritional and agricultural research, but the scope of such work requires to be greatly enlarged by the appointment of more officers of this type both by the Central and by the Provincial Governments.

8. Dr. V. K. Badami, Cuttack.

In regard to the suggestion to popularize the use of soya bean, experience with dozens of varieties has shown that attempts to introduce this crop and grow it successfully have invariably met with failure. Furthermore, it is rather difficult to cook this pulse or obtain a palatable preparation out of it. There is no reason why in its place people could not use groundnut which is a crop of the country and which, as has been shown by Professor Sahasrabuddhe, is at least as nutritious as the soya bean.

9. Dr. W. R. Aykroyd, Coonoor.

It does not appear a feasible thing to introduce the soya bean crop on any very wide scale. It would be far more easy to persuade people to make greater use of the pulses that are already being grown in the different parts of the country.

10. Dr. P. H. Carpenter, Tocklai.

The necessity for obtaining greater collaboration between the nutrition research workers and the agricultural research workers is recognized, but it may also be pointed out that the organization for such collaboration is in being. There are in existence, the Medical Research Council and the Agricultural Research Council and collaboration between these two bodies already exists. What is now required is for individual workers to make greater use of this collaboration by sending up more research schemes that deal with some of these fundamental problems.

11. Prof. N. M. Basu, Calcutta.

Crop Production in India in relation to Nutrition.

In a poor country like India where the bulk of the people cannot afford to have an adequate amount of nutritive foods such as milk, meat, eggs and fish, partly on account of their high cost and partly due to religious sentiments, the production of crops in various parts of the country should be so regulated that the optimum nutrition is possible at the minimum cost. Before, this is done, it is necessary to have a complete survey of the dietetic habits of people inhabiting different areas of the country. In this survey particular attention should be given to the staple food, the various accessories, spices and condiments taken with it and the different varieties of these produced in each area.

After this survey is done, the work of the various nutrition workers in each province should be harnessed in an organized and systematic attempt to find out the available Ca, Fe, and P contents of these foods, the biological values of their proteins, the digestibility of their carbohydrates and fats, the supplementary relations of the various foods, the total biological values of these mixtures of foods after being cooked in the customary way, the acid base balance in each food and their vitamin contents. The result of these analyses should then be made known to the Agricultural Departments so that the latter will be in a position to judge which crops should be produced in a particular area in greater abundance over others.

Isolated attempts have been made in several parts of India to find out some of these particulars. Thus of all the *dhals* green gram is found to be most nutritive and of the various kinds of rice, coloured and coarse-grained ones are richer in protein, P_2O_5 and ash content than fine varieties. Again the various cereals and *dhals* on combustion leave behind an acid ash and accordingly they should be taken with plenty of vegetables which, as a rule, leave behind an alkaline ash. Further, rice and *dhals* show supplementary relations with regard to growth. Of the various leafy vegetables, spinach and the leaves of white gourd are rich in carotene but as the former contains a very high percentage of oxalates, it should be taken with caution particularly by the aged. The vitamin C content of the various fruits is too well known to need special mention. Although apples, strawberries and raspberries are good fruits in various respects, yet their juices, being highly rich in potash should not be taken either regularly or in large amounts by persons with cardio-vascular symptoms. Of the various spices, black pepper is found to be markedly rich in available Fe and vitamin B_2 (ribo-flavin).

The knowledge that has been gained already with regard to these various foods is of considerable value to the agriculturists, but it cannot be denied that a systematic attempt in the elucidation of the various problems mentioned above would be of further importance to the agricultural department in regulating crop production in India and would go a long way in solving the problems of nutrition of the poor people.

12. Mr. A. C. Ukil, Calcutta.

Quality in crops has a relative connotation. To an agriculturist, it means high yield coupled with the power of resistance to insect attacks, diseases and other harmful environmental conditions as well as cheapness in production. To one interested in the health of the nation, quality is determined by the nutritive value of the Food Crops and by their disease-preventing propertes. To the public in general, however, it will mean everything, i.e. high yield, clean appearance, cheapness, possession of the required nutritive value, and availability in adequate quantity.

Agriculture is assuming more and more importance in sociology. The nutritive value of farm products is as important as their general

appearance and cheapness. In its agricultural aspects, the variety of grain, kind of manure, soil, irrigation, season, climate and other environmental factors, all assume importance. In the matter of nutrition, the composition, enrichment both of quality and quantity, keeping properties, cheapness, supply and distribution are important considerations. In the socio-economic sphere, the dietary habits of the people. their economic status, education and other factors are to be considered. In the sphere of statecraft, the distribution of land for agriculture, horticulture, fodder and forests in relation to the population, the creation of marketing facilities, crop planning, raising the economic level of the peasant, the development of irrigation and communications, rendering available more land for cultivation, control of population, and suitable legislation are some of the important items for consideration.

It is a matter for regret that the application of very useful researches to agriculture has lagged behind in India owing to a lack of planning efforts and implementation by the State. Unless this lag is removed, it will be futile to continue the academical discussions at the Indian Science Congress meetings year after year.

13. Rao Bahadur T. S. Venkatraman, Coimbatore.

In nutrition experiments, tests on human beings like school children in hostels, are more useful than those on rats whose mentality we do not know.

When evaluating diets for vitamins, even small differences in quantity will make big differences in nutritive quality. The effect of vitamins is comparable to that of emotions on human audiences.

14. Mr. K. Mitra, Patna.

Efforts at assessing quality in crops through animal experimentation should, wherever possible, be justified by human biological experiments. It is true that human experiments are rather difficult to carry out successfully, but the difficulties must be boldly faced by those genuinely interested in the matter. In evaluating the results of nutrition work on animals, one has to take into account the digestibility coefficient, biological value, acid-base balance, etc., but human growth experiments do away with these difficulties.

15. Prof. N. M. Basu, Calcutta.

Almost all the important discoveries in the field of nutrition have been carried out with rats as the experimental animals, but the need for confirming these findings through proper experiments with human subjects should be realized more fully.

16. Dr. V. G. Panse, Indore.

Experiments with human beings, specially school children, are often vitiated by uncontrolled factors. For instance, in one test recently carried out at Indore on the effect of milk supplements, the absence of any difference in growth between the milk-fed and control groups at the end of the test was traced to the fact that the children of the latter group got their milk at their own homes!

17. Dr. K. P. Basu, Dacca.

Quality in Pulses and Cereals.

The nutritive value of the different varieties of pulses and of rice has been the subject of intensive investigation in the biochemical laboratories. Dacca, for a number of years.

Pulses: Indians as a rule, take very little of animal proteins and the bulk of the vegetable proteins they take is derived from the pulses. The protein content of the pulses generally varies between 23 and 30%, with the exception of the soya bean which contains 41-42% protein. The value of a particular pulse—and indeed of any food-stuff—as a source of proteins is determined not only by its protein content but also by the digestibility and the biological value of its proteins. The digestibility of the pulse proteins varies between 85 and 91%. The biological value of the lentil proteins is only 32, that of soya bean is 58 and in the other cases the value lies between 46 and 52 at 10% level of protein intake. The net protein value is 20·2 in the case of soya bean and in the other cases varies between 6·5 (lentil) and 14·4 (*Lathyrus sativa*).

The increase in body weight of young animals for each gram of protein intake from a particular source is also a measure of the quality of proteins from that source. At 10% level or protein intake, *Lathyrus sativa* induced no growth, while other pulses induced growths from 1·5 gm. (soya bean) to 0·9 gm. (lentil) in young rats.

The quality of pulse proteins can, in most cases, be improved by incorporation of small amounts of milk. Aman rice proteins also show a supplementary relation towards some pulse proteins.

The mineral content of the pulses varies from 4·5% in the case of soya bean to 2·2 in the case of lentil. Soya bean contains the maximum amounts of calcium, phosphorus and iron. All the pulses are acid formers and the potential acidity is the least with the green gram and highest with the lentil.

The total percentage of carbohydrate is 21·5 in the case of soya bean and in the other cases varies between 49 and 57. With the soya bean only 8% is in the available form, with Bengal gram 36·2 out of 48·7% is available while the other pulses contain nearly all their carbohydrates in the available form.

The pulses are good sources of the B vitamins and soya bean is particularly rich. The only points against soya bean are its taste and the difficulty in making preparations with it.

Rice: Eighteen different varieties (pure line strains) of Bengal rice—both *aus* and *aman*—have been analyzed in these laboratories and the changes in the chemical composition of the grain as a result of husking, polishing and parboiling studied. The enzymic digestibility of the different strains has also been investigated. *Aman* varieties of rice appear to be more digestible than the *aus* varieties.

The biological value of the proteins of both the *aus* and *aman* varieties of rice is 80 while that of whole wheat is only 67. Parboiling has no effect on the biological value of rice proteins.

At 5% level of protein intake *aman* rice causes a very good growth in young rats—growth per gm. of protein being 2 gm.; *aus* rice induces no growth whatsoever while wheat causes a growth of 1·42 gm.

18. MR. A. SREENIVASAN, Indore.

Quality in Rice.

It is generally held that rice is a poor article of diet and that it is not possible to alter its food value appreciably. It has even been suggested that rice should, in part at least, be substituted by some other cereal like wheat. But the poor quality of the rice, as ordinarily consumed, is largely traceable to the choice of wrong varieties, to refined conditions and to the prevalent practices of washing and cooking involving considerable losses of nutritive elements. Thus, although the fine-grained and white varieties of rice are generally favoured by consumers, it has been found that some of the coarse and coloured varieties contain larger quantities of protein and mineral ingredients and possess thicker bran

layers. Again, the losses in nutritive constituents as a result of washing prior to cooking of rice is not generally recognized and may be quite considerable especially when reckoned with the losses on polishing.

In the process of polishing of rice, more than half the mineral matter of the grain and a fourth of the protein are lost while the fats and vitamins are almost entirely removed. Polished rice has a pleasing appearance and texture, it cooks more easily than the unpolished grain and, it is believed, digests better; in the unpolished condition, it has far better keeping quality and can be stored for long periods or transported over long distances without appreciable deterioration.

In vitro digestibility trials have, however, shown that the difference in digestibility between unpolished and polished rice is too small to be of any significance in practice; further, it is possible by suitable control of humidity and storage methods to prevent or at any rate greatly minimize the deterioration of hulled rice on storage. On account of the thick bran layers, unpolished rice is no doubt somewhat slow to cook but this defect is more than compensated by the bigger return of shelled rice and by the fact that, bulk for bulk, cooked unpolished rice contains more solid matter and has far more sustenance than cooked, polished rice. The consumer will thus stand to gain not only in the quality but also in the quantity of available food material.

It is also possible, within limits, to increase the protein and mineral contents of the rice grain by cultural methods. Rice protein has a biological value higher than that of most other cereals including wheat and a large part of the phosphorus present in rice is also, according to recent evidence, available to the human system.

Parboiling of rice improves its food value in that even after milling, such rice retains more of the essential nutritive constituents than the corresponding raw rice. This has been shown to be due to the absorption of these constituents from the integuments by the endosperm and to the facts that commercial parboiled rice is usually undermilled and that, for parboiling, coarse rices are often used. Parboiling also results in a high increase in the yield of head rice on milling. Furthermore, parboiled rice has a better keeping quality than raw rice even in the unpolished condition. There is thus every reason to hope that the production and use of parboiled rice should become more extensive than has hitherto been the case.

There is great need for educating the public in regard to methods of improving the status of the rice diet and thus ensuring better growth and greater improvement in the general health and well-being of the rice-eating population of the world.

19. Dr. K. Mitra, Coonoor.

One should not lose sight of the fact that by faulty or uneconomic methods of cooking or by milling, a good deal of essential elements in cereal grains are lost. Certainly, it would not be a desirable proposition to ask the agricultural experts to improve the quality of crops while the people for whom these improvements are effected, are losing a part of the essential elements through the practice of consuming milled grains or by faulty methods of cooking.

20. Dr. K. V. Giri, Waltair.

Manurial trials have shown that only the nitrogen or the phosphorus content of the rice grain can be altered this way. Rice is usually well represented in regard to these constituents. What is important is to aim at enriching, by cultural or other means, the calcium content of the grain.

21. DR. A. SREENIVASAN, Indore.

The calcium : phosphorus ratio of almost all the cereals is abnormally high; this is the chief reason for the well-known rachitogenic action of all cereal diets. Efforts at improving cereals as a source of calcium are not worth while and this element should only be supplemented from other sources.

22. RAO BAHADUR VISWA NATH, New Delhi.

Increase in nitrogen content of grains as a result of manuring is usually followed by a decrease in the phosphorus content while increase in phosphorus content does not result in a decrease in nitrogen.

23. DR. V. K. BADAMI, Cuttack.

Over 90% of the bran samples obtained from the rice mills are adulterated with the rice hulls and are, therefore, injurious as animal feed.

24. MR. P. M. KHAREGAT, New Delhi.

It will be a difficult task to get over the habit of polishing rice; experts should, therefore, aim at providing cheap and efficacious supplements which can make a polished rice diet balanced and perfect.

25. MR. P. E. LANDER, Lyallpur.

Quality in crops for feeding purposes.

The speaker indicated the progressive increase in our knowledge of those factors which have come to light in recent years and which play an important part in determining the quality of a fodder crop. He showed that the ordinary quantitative table showing the chemical analysis, such as was accepted as satisfactory some years ago, has undergone considerable revision. One of the most important factors constituting quality of a crop, namely, the protein, is dependent on the nature or make-up of the proteins and the degree to which they can be utilized in the organism. Similarly the type of fat in a fodder does influence the body fat of the animal. Thus, feeding a ration whose fats contain an undue percentage of unsaturated fatty acids may tend to softening of the body fat. Again, in regard to influence of fat fed on milk production, experimental evidence indicates that within reasonable limits, a reduction or variation in the amount of fat fed may tend to reduce the yield but not the fat percentage, the constancy of which appears to be a special effort of the animal economy.

It is shown that the mineral constituents of a crop are also of supreme importance not only as regards the actual quantitites present but their ratios. This applies particularly to calcium and phosphorus and to the total acids and bases. No discourse on the 'Quality in Crops' can be complete without due recognition of the part played by minute quantities of minerals not ordinarily recognized in the analysis of crops. This can only be estimated properly by spectrographic methods which should be developed accordingly.

The important part played by Vitamins and their relationship to the other constituents of a crop are also reviewed. Attention is drawn to the fact that these qualitative aspects of crops vary considerably during the various stages of a crop's growth and also, in the case of fodder crops, with succeeding cuttings.

26. Dr. K. C. Sen, Izatnagar.

Quality in crops with reference to fodder and feeding stuffs.

In a country like India where animal husbandry occupies a very important position in agricultural operations, the production of good quality fodder crops has not as yet received adequate attention. Until recently, we did not raise much crops for the sole use of cattle and we were content with the by-products of aerable agriculture, such as cereal and millet straws and the scant pasturage which is available in many places for the feeding of animals. Even at the present time, taking into account the limited amount of fodder crops produced solely for cattle, it has been found that the amount of cattle feed available in this country is only about 55% of the requirement. This does not include the indigenous grasses available, the quantity of which cannot be accurately estimated. Thus, for a part of the year at least, the animals must be getting insufficient amount of food. Apart from the question of quantity, the food is deficient in quality. The available amount of digestible protein is about 1/8th the amount required, total digestible nutrients 1/3rd and the nutritive ratio unusually wide. The roughage is thus of poor quality and is very often devoid of any vitamin A potency. In consequence there has been a wide prevalence of malnutrition which is the greatest single factor of importance in the causation of the degeneracy of our animals. It retards growth, delays sexual maturity, gives rise to emaciation and loss of working power, diminishes milk yield, brings about reproductive difficulties such as sterility, abortion, birth of weak or diseased calves, makes the animal more susceptible to infection and disease and increases mortality.

The provision of more and better quality fodder is therefore of urgent necessity and immediate attention must be paid to this aspect of crop production. Unless this is done, it is impossible to improve the condition of the working bullocks which are the mainstay of agriculture and which, in turn, will affect the efficiency of our crop production organization including food and cash crops, and will severely limit the return from the land. The bullock labour is practically the only motive power which drives the agricultural machine of our country and its inefficiency will naturally show its effect immediately.

27. Rao Bahadur T. S. Venkatraman, Coimbatore.

Sugarcane tops are valuable as fodder to cattle and in South East Australia, sugarcane is grown merely for use as fodder.

28. Mr. A. M. Livingstone, Delhi.

Quality Standards.

Price is a simple index of market quality—*ceteris paribus*—the higher the quality the higher the price. One of the main problems in agricultural marketing is to ensure that producers secure an adequate premium for improved quality.

Legislation of various kinds bearing on the question of quality exists in the form of Cotton Ginning and Pressing Acts, Food and Drugs Adulteration Acts and the Bombay Cotton Contracts Act. These Acts are not designed primarily in the interest of the producer-seller and probably function more as a protection to the buyer. The recent Merchandise Marks Act passed in the interests of sellers of certain brands of articles has only a very limited application to agriculture and does not affect the main problem.

The first obvious step is to define quality and provide some means of identifying articles which are of higher quality than others. Quality may be defined with reference to certain minimum requirements of the market or as something in the nature of a fair average or as a series of grades covering the various gradations in quality of a particular product.

Characteristics of quality are usually defined according to certain intrinsic factors such as length, fineness, colour and strength of fibre as in cotton, wool and jute, or simply as size and freshness in the case of eggs, or size maturity and freedom from blemish and disease in fruits, or purity of type, freedom from dirt and damaged grains, etc., as in the case of cereals and oil-seeds. Apart from the intrinsic characteristics of a product it is also necessary to define the nature of certain other factors to ensure that it is well made and free from adulterants. This is particularly necessary in the case of butter, ghee, edible oils, coffee and foodstuffs generally.

The necessity also for some forms of distinctive marking would be evident in regard to products in the last category and to all articles in tins or other closed containers. Indeed this applies to all cases where a buyer does not see the goods at the time of purchase or is unable to appraise the quality without, say, a close physical or chemical examination. It is essential, however, that a common system of marking should be adopted so that the same mark applies everywhere to the same standard of quality of any product.

From this circumstance arises the necessity for the Agricultural Produce (Grading and Marking) Acts adopted in many countries and for the corresponding Indian Act passed in 1937. Under this Act standards of quality and grade designation marks (AGMARK) have been applied to a wide range of agricultural commodities. Over 1½ crores rupees worth of standardized graded produce bearing the AGMARK have already been put on the market by packers operating at over 200 centres. Careful tests show that as compared with the same produce sold in the ordinary way ungraded, the standardized AGMARK products have in practically every case secured enhanced prices sometimes even more than 50% above the ungraded article. The problem of securing a premium for quality is therefore on the way to solution, but a much more extensive practical application of the Act is called for.

29. Dr. P. H. Carpenter *and* Mr. C. J. Harrison, Tocklai.

Quality in Tea.

This paper commences with a discussion of the meaning of quality, as applied to tea, and describes the methods employed in practice, in assessing tea quality. It is shown that the only definition of tea quality of any practical use, is value on the market, and this involves a consideration of the appearance of the dry tea as well as the taste and appearance of the tea liquor.

The manner in which the methods of evaluating teas in commercial practice have been adapted to the experimental study of factors affecting tea quality is described and it is shown that the results are capable of statistical analysis with a high degree of accuracy.

It is pointed out that the production of tea is a combination of agricultural and manufacturing processes, and that subsequent to the final stage of manufacture, the finished article may still undergo changes which affect its quality.

The factors influencing tea quality are conveniently divided into three groups:

(1) *Pre-manufacture influences.*—These include all those factors operative up to the point when the green leaf is landed at the withering house. They include *jat* (or variety of plant), soil type and condition,

styles of pruning employed, manuring, degree of shading, climatic conditions and many other factors known and as yet unknown.

(2) *Manufacturing conditions.*—These include all variations in the procedure of converting green leaf to black tea; variations in condition of the atmosphere in the factory and withering house, variation in types of machinery used; influence of certain types of micro-organisms; and many other factors.

(3) *Post-manufacture influences.*—After the tea has been packed it may still undergo considerable change under different conditions of packing and storage, temperature and moisture content of the tea probably playing a major part.

The effects on tea quality of all the various factors referred to above are discussed, and certain experiments are described in detail.

Finally, the chemistry of tea and its relationship with quality are described and discussed. Attempts at correlation of various chemical constituents with tea value are described.

30. Dr. V. G. Panse, Indore.

Quality in Cotton.

Difficulties in defining and measuring quality, which exist in several crops, have been almost entirely overcome in cotton, and spinning tests performed under standard conditions in the experimental plant at the Indian Central Cotton Committee's Technological Laboratory at Bombay are now a routine. The quality of cotton depends primarily on the strength and fineness of yarn and also on its appearance, i.e. on evenness, freedom from neps, etc. These properties have been shown to be strongly correlated with the length and weight of the cotton fibres. This result enables the breeder to test a large number of strains in the early stages for their probable spinning value and discard most of the unpromising material without the necessity of spending a lot of time and labour on multiplying it. The breeder needs rapid methods of measuring fibre-properties to help him to handle a large amount of material. Halo-length measurement on combed seeds as an estimate of fibre-length is an example of such methods.

Three species of cotton differing in quality are grown in India. Of these, G. *herbaceum* which is restricted to a small area in the West, and G. *hirsutum* which is generally grown only under irrigation, are superior in quality to G. *arboreum* which forms the bulk of the Indian crop. As the foreign market for this last type of cotton has considerably dwindled during recent years, the improvement in the quality of Indian cotton has become an urgent problem. The Indian Central Cotton Committee is devoting a large part of its efforts on the breeding of superior quality strains in different parts of India, and there is evidence of some improvement having already been achieved.

The success of improved strains in the long run will naturally depend on what quality is worth to the grower. It is the experience of breeders that any large improvements in quality are frequently accompanied by loss in the yielding capacity or the ginning percentage of the strain. Investigations at Indore have demonstrated that the premium obtainable for superior quality is generally too small to compensate any appreciable loss in yield. It follows that in recommending superior quality strains to the grower, care must be taken that these are not inferior in yield to the variety it is proposed to replace.

The fact that the premium on quality is very low does not mean that the buyer is unwilling to pay an adequate price. Cotton prices all the world over are closely linked together, and the price available for Indian cotton of a particular quality depends, among other things, on the size of the American crop. The net result is that the trade cannot be expected

to pay any appreciable premium for quality, and this must be borne in mind by those concerned with the improvement of quality of Indian cotton.

31. DR. J. S. PATEL, Dacca.

Quality in Jute.

According to commercial opinion a good quality fibre should be strong, fine, lustrous, long, free from roots, clean and of good colour. The rôle that these characters play in determining the spinning quality is explained. The influence of various factors on the quality is dealt with. For the production of good quality fibre it is essential to take reasonable care in the cultivation and preparation of jute. Absence of proper weeding and thinning result in thin and weak plants of irregular height. Uneven steeping and careless stripping and washing lead to the formation of runners, a condition in which the strips of outer bark adhere to the fibre. Specky fibre where patches of bark adhere to fibre is caused by uneven retting and insufficient washing.

The time required for retting depends on a large number of factors such as the type of retting water, the stage at which the crop has been cut, depth of immersion, size of bundle, ratio of straw to water, temperature and the variety of jute. In stagnant water, the retting is quicker. Plants retted in water where other plants have been previously retted, take less time. Jute cut before maturity rets quicker.

The quality of jute is also affected by soil conditions. A coarse fibre is obtained from sandy soils whereas clay soils yield a short crop and the plants do not ret properly. Loamy soils produce the best crop.

So important is the influence of edaphic factors that the jute in commerce is graded according to the place of its origin. Apart from the differences in quality between the two species, *oliforius* and *capsularis*, which are recognized, varietal differences either do not exist or are so small that they are masked by the play of edaphic factors.

Experiments are under way to analyze the influence of varieties, growth conditions and retting water on the quality of fibre.

32. DR. N. G. CHATTERJI, Cawnpore.

Quality in Oil-seeds.

Quality in oil-seeds is judged mainly from two points—the quality and quantity of oil obtainable, and the quality and quantity of the oil-cake left after removing the oil.

Obviously these considerations are likely to be influenced from the commercial point of view by a number of factors, of which the following may be mentioned:—

1. The proportion of the total oil that can be expressed or extracted out from the seed, depending largely upon the nature of the oil-bearing cells and other portions of the seed.
2. The non-oleaginous matter associated with the raw oil, and the extent to which these are removable by the ordinary refining processes. This has assumed great importance during recent years on account of the rapid increase in the hardened oil industry.
3. The cattle-feeding qualities of the oil-cake, depending upon its digestibility, proteid content, non-toxic nature even on storage for a length of time.
4. The suitability of oil-cakes for particular industrial purposes.

In considering this subject, the oil chemist would perhaps be interested in the study of the influence of soil, manure and climatic conditions on the constitution and relative proportion of the various glycerides forming the oil. the agriculturist in finding out whether any extra expenses incurred in manures and cultivation give increased profits worth the trouble, the economist on the disturbance in the internal and external markets likely to be created by increased production or bringing new areas under cultivation, and the politician with the vagaries of his brotherhood in creating artificial restrictions against the ordinary economic laws of supply and demand.

33. MR. M. ALAM, Sabour.

Quality in Rice with special reference to fineness.

Quality in a crop could be classed into the following sub-heads:—

(1) Grain quality: Colour and size of the grains.
(2) Cooking quality.
(3) Hulling quality: Breakage, husk and grain ratio, etc.
(4) Aging or storing quality: Change in appearance or in cooking quality after storage for a few years.
(5) Aroma or flavour of the grains.
(6) Food value, i.e. percentage of carbohydrate, protein, minerals, etc.

It is not necessary that all these aspects should have equal importance for all purposes and from all points of view. It is further possible that the same aspect of quality may have different importance for different classes of consumers. Thus, with rice, some consider long, fine grains to be the best in quality, whereas others prefer the short, bold grains or the medium, fine ones. Similarly cooking quality or aroma has different standards for different classes of consumers. The cooking quality required for the rice prepared by ordinary cultivators for everyday use is very different from what is required for preparing table rice or *pulao* used by the middle or higher classes. Similarly one particular flavour may be very much liked by some, but the same may be disliked by others.

Quality in rice has, therefore, to be dealt with from at least two distinct points of view, namely:—

(1) When used as a main diet.
(2) When used for special preparations like *pulao*.

The grain quality and cooking quality required in the first class is very different from what is required for the second one. Besides this, the food value of the grains also assumes considerable importance with the former, whereas aging and aroma is of greater importance with the latter. The problem of quality, as required for the first purpose has been receiving considerable attention in recent years—especially in Southern India—whereas the second one has not been studied except for a beginning that has been made in a few individual provinces. No one has actually been able to say as to what really determines the so called quality of the reputed fine rices, which fetch so high a premium over the ordinary rices. The fineness of the grain alone is certainly not responsible for this as in each tract we come across a large number of ordinary fine varieties like *Basmati*, *Hansraj*, etc., among U.P. rices, and *Shamzira*, *Tulsimanjri*, *Badshahbhog*, etc., among the Bihar rices. Another characteristic of the reputed fine rices is their aroma or flavour, which counts a good deal in determining their quality; the question arises as to what constitutes this aroma or flavour and whether such rices differ in their physical properties like shape and size of grains, water or fat absorbing capacity, etc., or not. There are other characteristics of these fine rices such as aging, milling

and cooking quality, etc., which also need careful investigation. The varieties with best cooking quality do not allow the cooked grains to form a mass, so that even after cooking each individual grain keeps its identity—though elongating considerably and at times changing its shape.

The reputed fine rices are believed to be capable of retaining these 'qualities' only in certain restricted areas and there is a general belief that the same fine varieties when grown in localities even a few miles away from those to which they originally belong, not only lose their cooking quality but also get coarser and look different. It is this aspect of the problem which needs very careful investigation as it has, more or less, shut out the possibility of growing these reputed fine rices in tracts other than those to which they belong or even to extend its area in the same tract. Some preliminary investigations carried out under Bihar Rice Research Scheme have more or less established that these reputed fine rices could successfully be grown in absolutely new tracts without any change in their physical properties like size, shape, etc. A complete study of the problem, however, needs a more systematic investigation by growing a few of the reputed fine varieties in a few widely distinct tracts and seeing if there are any changes in the properties that go to denote quality in them.

In so far as the inheritance of these quality characters are concerned, we are still in darkness and the inheritance of such characters as aroma or flavour, cooking quality, etc., has not at all been studied. Ordinarily one is apt to think that the problem is of importance only to the higher and wealthier classes of men, who use these fine rices in making *pulao*, but actually this is not so as even the poorest cultivator is anxious to set aside, at least, a portion of his land for growing these rices, which bring him much higher price with very little extra care.

34. DR. B. P. PAL, New Delhi.

Quality in Wheat and Tobacco.

Quality is a relative term and has reference to many characters. In general so far as the food crops are concerned, soundness, keeping quality, nutritive value, palatability, low waste, and attractiveness, constitute quality. In wheat, the so-called hard wheats or strong wheats, i.e. those whose flour is capable of producing a well-risen loaf of bread are generally preferred, both in India and abroad. For special purposes, however, e.g. biscuit manufacture, poultry feed, etc., soft wheats are preferred. Again for making macaroni and similar preparations, the extremely hard-grained *durum* wheats are used.

Quality in tobacco, again, is judged differently according to the purpose for which it is intended. Coarse, dark, strong-flavoured, thick leaf is preferred for chewing and for use in the *hookah*. On the other hand, tobacco leaf intended for cigarette manufacture should be thin, of a bright lemon to orange yellow colour, and of a pleasant aroma. Tobacco requirements are again different as regards cigars: here the tobacco for the filler, the binder and the wrapper should possess certain distinctive characters and special varieties are grown to supply these varying needs.

35. DR. GILBERT J. FOWLER, Madras.

The use of the Activated Sludge Tank for Agricultural Experiments.

Scientific research on nitrification in modern times is early associated with the name of Warington. He set out many of the essential conditions for the successful oxidation of ammonia to nitrate. In Warington's

experiments the process occupied considerable time, possibly weeks. It was Munro who showed that the process could be greatly hastened by systematically building up an active mass of the necessary bacterial culture.

Here Munro developed scientifically what the Chinese farmer had long ago discovered in what he termed 'mother of petre'. Later this principle was rediscovered and applied to what is now well known as the activated sludge process.

In the activated sludge tank it is possible in presence of sufficient well-conditioned activated sludge and of adequate air supply to convert ordinary domestic sewage into the innocuous end products of nitrate and humus in the course of a few hours and in an area less than 1% of that required for an ordinary sewage farm.

Apart from the rapid oxidation of the organic matter of ordinary sewage, other biochemical operations of interest to agriculture can be accelerated by varying applications of the same principle.

Thus by adding powdered vegetable refuse to the tanks the nitrogen in the effluent is immobilized and transferred to the sludge thus making both sludge and effluent of more value to agriculture, since under certain conditions an excessive nitrogen content may be detrimental if the effluent is used for crop irrigation.

By addition of powdered sulphur and rock phosphate the latter is rendered soluble and an effluent rich in phosphoric acid and poor in nitrogen is obtained.

The most recent use of the activated sludge tank for experiments of interest to agriculture is in the cultivation of crops in so-called 'Hanging Gardens', i.e. in suitably designed receptacles floating on the surface of the aeration tanks of the activated sludge installation.

The immediate interest of these experiments is in connection with 'Quality in Crops'. The discussion between the advocates of mineral fertilizers who may be termed the Liebig School and the organic manure supporters, who in view of his recently published book may be termed the Howard School, has recently become somewhat acute.

In order to obtain conclusive evidence on the question news has recently been received of an experimental station to be set up at the Haughley Research Farms, nr. Stowmarket, Suffolk, England, where the whole subject is to be carefully studied. It is anticipated that it may take 10 years before final conclusions are reached.

Meanwhile the following results have just been reported from the Indian Institute of Science, Bangalore. Here for some time experiments have been carried out by Mr. S. C. Pillai on what have been termed 'Hanging Gardens'. In these a number of typical plants were grown. The experiment was under way when aeration became impeded through temporary blocking of the diffusers. Immediately the effect was noted in the health of the plants. About a week was taken to clean up the diffusers and restart operations. During this period a number of the plants showed clear evidence of insect attack. On resuming proper aeration they quickly recovered and ultimately showed an extraordinary development of growth as compared with ordinary pot cultures. The following are typical examples:—

Ragi.—Tank growth average development of tillers, lateral branches and ears 12 times greater than the pot control.

Tomatoes.—In the case of tomatoes the tank growth showed 16 fruits as against 8 fruits in the pots.

Marigolds.—52 flowers in the tank and 9 flowers in the pot.

Of course, a great deal of confirmatory work needs to be done, but the results as they stand are in line with all Howard's contentions and with analogous experiments made several years ago.

It would appear, therefore, that valuable results could be obtained by the use of the activated sludge tank as an experimental apparatus for

greatly accelerating a number of changes which might take years to investigate by ordinary agricultural methods.

The President's concluding remarks :

Improvement for quality and for quantity do not always go together and circumstances alone can dictate whether quality is to be sacrificed for quantity or *vice versa.* At our present stage, when we have in our midst, under-fed men and animals, greater attention should perhaps be given for quantity rather for quality first. Expansion of market and transport facilities so as to enable proper distribution of agricultural produce and thus remedy dietary deficiencies in particular localities is also necessary.

On the question of inorganic fertilizers *versus* organic manures in relation to quality in crops, the solution appears to be fairly obvious: We should try a mixture of the two kinds. We have not enough farm-yard manure available and, if only for this reason, it does not appear to be a sound policy to reduce the number of cattle as this would still further seriously affect the supply of this valuable manure. As regards the proportions in which organic and inorganic manures are to be used for obtaining maximum benefit, it is a matter for experts to decide after suitable experimentation.

Reference has been made to the need for greater collaboration between the agricultural and nutrition research worker. We all agree with this. One step in this direction has already been taken up by the inclusion of the Public Health Commissioner to the Government of India in the Advisory Board of the Imperial Council of Agricultural Research.

The question whether we should reduce the production of human food crops so as to give room for more fodder cultivation to our cattle is a difficult one to answer. It must be admitted that the need is for more food both for men and cattle. A good deal of careful crop planning is necessary to solve out the difficulty. For instance, the acreage under cultivation of sugarcane in the U.P., jute in Bengal and groundnut in Madras should all be controlled so as to avoid over-production on the one hand and meet market requirements on the other. In this connection, it would generally appear necessary to increase the acreage under pulse crops since, as this discussion has shown, there should be greater consumption of the pulses by the masses. If, for some reason, the cultivator does not find pulse production paying, then ways and means of compensating him adequately will have to be devised.

XXV. NEED FOR THE EXPLORATION OF WILD FORMS FOR THE IMPROVEMENT OF CROPS.

(*Sections of Agriculture and Botany.*)

RAO BAHADUR T. S. VENKATRAMAN, Coimbatore, presided.

1. RAO BAHADUR T. S. VENKATRAMAN, Coimbatore.

Sugarcane.

If by any chance a field in cultivation happens to get neglected without the usual tilling and the sowing of agricultural crops, certain changes in the flora of the field occur which are of great interest to agriculture. Two of these changes are noticed below.

The field soon gets overrun with a large number of species of plants which differ widely from one another in such characters as size and shape of plants, depth and extent of root systems and obviously also their relative intake of plant food both in quality and quantity. This shows that in Nature the method of populating a piece of land with vegetation is to establish on it a certain number of different species of plants. Agriculture is an attempt to establish one particular species on such land to serve human needs.

Secondly, for the first year or two after the land is thus neglected, one might find a few plants of the previous crop from self sown seeds, but after a time these disappear almost completely being driven out by hardier types of vegetation, i.e., types which do not need the same care and attention that agriculture connotes. This shows that crop plants need special attention and care from man to keep them on the land against, what may be termed, its natural occupants. This is undertaken by man in return for the food and clothing which crop plants yield.

Though the gradational steps in the evolution of our present crop plants from their wild progenitors are not always clear, yet there is little doubt that the wild types represent the stock from which these crop plants have arisen. Briefly stated, this must have been through a process of selection from a large range of available variations with a view to meet man's needs and desires. The available wild types thus represent, as it were, the original widely varying range of characters of the crop plant, the crop under cultivation representing just one set or grouping of characters as the result of selection. Similar characters or the same in different combinations might, therefore, be expected to be available in the wild types. The only known method of tapping these to the advantage of the crop is to cross crop plants with such wild forms.

Coming to crop growing, the special and somewhat 'unnatural' conditions imposed by agriculture and all that it connotes raise certain problems both for maintaining the crop at its present level and for improving it. All agricultural operations including those connected with the control of pests and diseases represent attempts to overcome handicaps imposed by agriculture. If, in the course of the examination of the various problems that confront the breeder, he wishes to emphasize a particular character or bring out a new set of combinations, the obvious thing for him to do is to draw upon the wide variations available in the wild but related species. A collection of all the wild species and their close study is thus an obvious task for any crop breeder. Even in those cases where he is not yet able to employ the wild types as parents, their study gives useful ideas about the range and the limit of variations to expect with reference to his own crop.

One great obstacle to the proper utilization of the wild species is their non-crossability with the cultivated varieties While a fair amount of intercrossing between the wild progenitors in the early history of crop plants has to be assumed—and certain natural hybrids both in cultivation and in the wild state justify such an assumption—it would appear that the march of time has augmented original differences between the wild and cultivated types rendering them not crossable with one another in their present forms. Experience with sugarcanes would, however, indicate that there is room for further and more elaborate attempts in this direction with reference to all crops.

The benefits that have accrued to the sugarcane crop from hybridization with the wild *Saccharum* have been remarkable and should prove a pointer to the breeders of other crops to make efforts in a similar direction, however unpromising or difficult the task may at first appear. Such benefits cover almost every useful agricultural characteristic of the crop from germination and tillering to an erect and close stand at harvest, from a deep and well developed root system to a shoot growth that suits certain difficult environmental conditions, and from resistance to drought and waterlogging to resistance to frost and to certain pests and diseases.

Certain of these characters, such as resistance to adverse conditions in the environment, are of the type reasonably to be expected from the employment of wild parentage.

The value of these characters in the husbandry of the crop has been so marked that there is a growing desire to work into sugarcane breeding as many of the wild types as possible. Most of the present popular canes of both Java and Coimbatore have in them the blood of at least one wild *Saccharum* and in the case of some Coimbatore canes even two. The United States of America recently sent out to the wilds of New Guinea an elaborately equipped expedition for securing the wild ancestors of the tropical or 'noble' type of canes. The main object in this case was to breed against various diseases to which the canes in cultivation are getting increasingly liable. The introduction of such wild blood into the parentage of new canes might well be considered as an attempt to partially counteract the handicaps imposed by the rather artificial conditions consequent on agricultural-crop-growing and is essentially in the nature of a 'harking back to Nature'.

As was to be expected, the wild types have introduced certain undesirable characters like pithiness and greater impurities in the juice. These, it has been found, are rectifiable to a great extent by back-crossing with the better types of sugarcanes.

Results of sugarcane breeding possess certain features which may well have a wider sphere of utility. Not only have the cultivated canes crossed freely with the wild types but the hybrids have also generally proved fertile—not usual in other interspecific hybrids. This has made it possible to back-cross the hybrids with either of the parents according to the characters it is desired to emphasize. Secondly, the species with which it has been possible to cross the cultivated canes belong to genera other than *Saccharum* and in one case to the other sub-family of the *Gramineae* as in the case of *Bambusa*. Among other genera with which it has been possible to cross *Saccharum* are (1) *Narenga*, (2) *Erianthes*, (3) *Sorghum*, (4) *Zea*, (5) *Teosinte*, and (6) *Bambusa*.

Any explanation for this behaviour of *Saccharum* might give the key to the initiation of parallel hybridization in the case of other crop plants. It is now admitted that the cultivated sugarcanes are complex polyploids. Again considerable irregularities have been noticed in the meiosis of *Saccharum* such as the doubling of chromosomes on the mother side or the loss of certain of them. Science is now developing various means by which to artificially interfere and control chromosome inheritance through treatment with chemicals like cholchicine or with physical agents like heat, cold and irradiation.

To conclude, it would appear not unreasonable to hope that fortified with fuller studies of *Saccharum* and its wide-range hybrids it might yet be possible to increasingly employ the wild species in the case of other crop plants as well. The advantages are so obvious that such work deserves a front place in all crop-breeding programmes.

2. Dr. B. P. Pal, New Delhi.

Potato and Wheat.

The rediscovery of Mendel's laws of heredity in 1900 gave a stimulus to plant breeding, and numerous new forms of plants have been evolved by selection and hybridization. After a time, however, it became apparent that in many cases the limit of improvement by this means had been reached; the genes present in the existing varieties had been all utilized without attaining the ideal in several important respects. It, therefore, became necessary to discover or introduce new genes.

It has been found that in many crop-plants, wild or little-known allied species or varieties exist and in several instances these are highly

resistant or even immune from the devastating diseases which attack and destroy their cultivated relatives; some of these wild forms also possess other characters of great value to plant breeding. Recognizing the importance of the exploration of wild forms for the improvement of crops the agricultural departments of several countries, notably Russia and the U.S.A., have organized expeditions to various parts of the world to make collections of as many crop plants and their wild allies as possible. In this way valuable material has been gathered together.

In potatoes, specially striking results have been obtained. The Russian and other expeditions to Central and South America have revealed the existence of a large number of tuber-forming species, some of which possess valuable characters not found in the common cultivated potato, *Solanum tuberosum*. Among these new species are *S. demissum*, highly resistant to late blight and to frost; *S. Rybinii* resistant to virus diseases and having tubers with a short resting period; *S. phureja* which produces tubers under hot humid conditions and under short day; *S. andigenum* which grows over a very extensive area in S. America and is characterized by high yield, and a certain amount of resistance to diseases and to frost; *S. acaule* and *S. curtilobum* which are resistant to frost, etc. The discovery of this material has entirely revolutionized potato breeding and opened new horizons.

In wheat, several grasses, e.g. the perennial couch grass and *Aegilops*, have been crossed with cultivated wheats. The cross with the former is regarded as specially promising, and holds out the prospect of creating varieties able to withstand the severe conditions of Siberia; there is also the likelihood of the production of perennial forms of wheat from the same crosses.

In India, no thorough survey has yet been made of the wild forms of the cultivated crops. India is the centre of origin of several crops and possessing as it does a wide range of conditions varying from intensely cold, snow-bound regions to extremely hot regions, and from areas of no rainfall to areas possessing the highest rainfall in the world, there is every reason to hope that such a survey would disclose material of priceless value to breeders and geneticists.

3. Mr. C. M. John, Coimbatore.

Oil-seeds.

When the improvements of crops effected with material available from the ordinary collection of varieties fall short of requirements, the need for utilizing wild or hitherto unknown forms possessing qualities not found in the usual cultivated varieties, suggests itself to the crop breeder as a possible line of approach. This course seems to be of special application to the solving of numerous problems of oil-seed agronomy and is expected to hasten the improvement work on oil-seeds that has been in progress in this country for over a decade.

In South India, the oil-seed crops that figure prominently in agriculture and trade are groundnuts (3½ million acres), Sesamum (7½ lakhs of acres), coconuts (5½ lakhs of acres), and castor (3 lakhs of acres). The problems as they affect the breeding and improvement work done on these in Madras are indicated below.

In groundnuts (*Arachis hypogea*) about 100 varieties exhibiting variation in habit of growth, duration, yields, nature of pods, shelling outturn, colour of kernels and oil content have been collected. High yielding strains of bunch and spreading types of plants have been evolved by selection. Cross breeding has been attempted to obtain new combinations of economic characters. Aspects such as strong pod attachment which would facilitate easy harvest of plants with the underground pods remaining attached to the vines, seed dormancy which would eliminate

loss caused by the sprouting of seed in soil due to the receipt of rains at harvest time, and resistance to wilt, clump and insect pests are problems that await solution. A general survey of the existing material indicates dearth of suitable basic material. There is evidence to show that in South America, there are types or species unknown in India and it is very likely that an extensive search in such areas would reveal the existence of new forms that would ultimately be of use in breeding work.

Sesamum or til (*Sesamum indicum*) is generally a three months' crop in South India and is cultivated in different seasons. The varieties in most cases are season bound and are therefore not interchangeable. Though the available varieties exhibit fairly wide variation of economic characters, non-lodging types possessing uniformity of ripening and varieties with non-dehiscent capsules are lacking in the Indian varieties. Africa is said to be the only area of distribution of almost all species of the genus *Sesamum* including wild forms and a search in Africa and India seems necessary for a representative collection. Recently a wild type of *Sesamum* has been collected from the low-lying hills on the West Coast of Madras and it has been found to be a vigorous growing type thriving in the shallow poor laterite soils of the hills.

Coconut (*Cocos nucifera*), unlike other oil-seeds, is a perennial crop and breeding requires a considerable time for achievement of results. There are at present about 20 different varieties of coconuts growing in Madras. Hybridization has shown immense possibilities, particularly in a cross between the ordinary tall type and the dwarf early type, wherein the F_1 has combined the desirable qualities of both the parents. A search for more varieties in the coconut area extending from Madagascar to the Philippines would probably result in the finding of new and interesting types. Seven other species of *Cocos* have been recently reported from Bahia in Brazil as useful sources of oil, wood, fibre and fodder.

Castor (*Ricinus communis*) being a highly cross fertilized crop is polymorphic but lacks in types which would be useful in solving some of the immediate problems such as hardiness to withstand excessive rainfall or drought during early stages of growth and resistance to insect pests and fungoid diseases. These two problems are becoming increasingly important as the spread of some of the very heavy and prolific bearing strains evolved in Madras is being very largely checked by them. The only remedy seems to be to hunt for disease resistant types. The original home of castor is located somewhere in India or Afghanistan and a search in the representative castor tracts of these countries has to be made for locating desirable types.

Thus though the requirements of breeding material for different crops are not identical the mode of attack, so far as the utilization of wild forms is concerned, is almost the same. It is considered desirable that the crop breeder who is interested in any particular crop explores its original home for the different varieties of the crop and the allied species, so that he may utilize to the best advantage the seed material for solving the many and varied problems that confront him.

4. MR. ALI MOHAMMAD *and* MR. SAWAN MAL SIKKA, Lyallpur.

Oil-seeds.

The importance of exploring wild forms of plants for the improvement of crops in general and with particular reference to Indian oil-seeds is discussed. The greatest use of wild forms lies in the fact that they furnish genes which could be bred into new varieties capable of resisting diseases and withstanding the effect of drought and cold. Counting on Vavilov's principle of group immunity of geographical races, further improvement in our existing varieties of oil-seed crops could be effected

firstly by making a careful study of their wild ancestors with regard to their power of resisting the attack of diseases, cold and drought and then by hybridizing the most desirable forms from amongst them with our present-day cultivated species. The sterility of the first generation hybrids, obtained by crossing of allied species or geographical races, should on no account be a block to further progress, as several methods are now known by which the fertility of the sterile hybrids could be easily restored. It is suggested that the Imperial Council of Agricultural Research will interest itself in the problem and set up suitable agencies for collecting wild forms of crops for use by plant breeders in India.

5. MR. K. RAMIAH, Indore.

Cotton and Rice.

Cotton :

There are now 19 recognized species of *Gossypium*, both cultivated and wild, some belonging to the 26 chromosome group and others to the 13 chromosome group. Of the above, only 13 are really wild species. Several crosses between the wild and cultivated species have been studied recently and a certain amount of knowledge gained about the relationships of the species mainly from the degree of chromosome conjugation in F_1s.

Though the wild species do not appear to possess any of the useful characters for which cotton is cultivated, on the analogy of studies with wild species in other crops, the breeder might expect to get from the wild types such genes controlling resistance to diseases and insect pests and general hardiness for incorporation in the cultivated forms. Owing to the difficulty of sterility in F_1s of several crosses between wild and cultivated species only two crosses which do not show such sterility have been studied extensively, one with *G. tomentosum* (26 chromosome group), and the other with *G. anamolum* (13 chromosome group). Whether physiological characters like resistance and hardiness can be transferred from species to species in the same way as morphological characters appears to be doubtful from the limited experience available. Our knowledge about the genetics of wild species is still very scanty and probably as this knowledge advances, there might be greater scope of making use of wild types for economic ends.

The work on *Gossypium* has however brought to light several instances in which certain forms or types have proved more useful for breeding purposes in tracts other than their home and from this point of view it is highly desirable that the breeder collects and maintains a large collection of varieties and geographical races and subject them to a process of acclimatization.

Rice :

All the cultivated forms of rice belong to the single species, *Oryza sativa*. A comprehensive botanico-geographical survey of the genus, *Oryza*, particularly in India and the eastern countries has not been made and the available information regarding species and their distribution is still meagre. Only a few wild species of *Oryza* are so far known and the number of inter-species crosses actually studied is still fewer.

Work in Coimbatore has shown the possibility of obtaining drought resistant types from crosses with the wild species, *O. longistaminata*. The diseases of rice in spite of their importance have not received any considerable attention still in India and breeding for disease resistance has so far been confined to crosses within the species, *O. sativa*. It is quite possible that some of the wild species may have some useful genes from this point of view. An exploration of such possibilities can only be made when a sufficient collection of wild species has been made and

studied. From the knowledge of the distribution of *Oryzae* and a section of the closely related tribe *Phalaride* the tracts likely to prove useful for exploration are S. India, Central and S. Africa, N. Australia and Indo-China. Because of the extreme importance of the crop to India, it is very desirable that at least the exploration of the region within the country itself should be taken up immediately.

6. MR. A. C. JOSHI, Benares.

Fruit Trees.

Explorations by Russian botanists in Central Asia and Caucasia have led to the discovery of numerous wild and semi-cultivated varieties of plums, apricots, peaches, almonds, cherries, apples, pears, grapes, walnuts, etc. Most of these varieties were previously unknown to science and are endemic to these regions. Many exhibit great hardiness, resistance to drought, frost and several diseases. Some also show good quality and flavour. For these reasons they have proved of great value in breeding work. As a result of their discovery large areas formerly barren have been brought under cultivation and turned into profitable orchards.

Three out of the eight 'primary centres of origin' of cultivated plants recognized by the Russian workers border on India. These are: (i) Central Asia, (ii) mountains of Eastern and Central China, and (iii) the Indo-Malayan area. A fourth centre falls in this country itself, namely, N.-W. India and Afghanistan. Most of the Old World fruit trees have originated in these regions. India is, therefore, in an exceptionally good position to organize the exploration of new varieties of Old World fruit trees. This may lead to the solution of many of our important horticultural problems, which cannot be solved by other methods. Our Citrus orchards are attacked by numerous insect pests and fungal and bacterial diseases. Exploration in north-east border of India and China, the original home of this genus, is likely to lead to the discovery of varieties resistant to these diseases. The problem of 'alternate bearing' in mango may be solved by carefully observing the yield of a large number of trees in this country and the Indo-Malayan region and discovering varieties bearing fruit every year. Wide explorations of this type would greatly help in extending the area of fruit cultivation in this country by discovering varieties of different fruit trees suitable for growing under different climates.

A point deserving special consideration in future exploration and introduction of new varieties of fruit trees is the vitamin content and the amount of other nutritive principles in the edible parts of the fruits. This has not received much attention in the past, but may be extremely important for the health of the nation.

7. DR. H. K. NANDI, Jorhat (Assam).

General Crops.

It is the common experience of breeders of crop plants that the limit of improvement within a species by intraspecific hybridization and selection is soon reached by the combination and recombination of the constant stock of genes, without the ideal types having been obtained.

A study of the commercial varieties of potato by Bukasov disclosed the limited possibilities of improvement. As a result of botanico-geographical studies by Vavilov and his associates in Russia expeditions were sent to Central and South America, the centre of origin of potato, and this led to the discovery of 18 new cultivated species and 65 wild species comprising about 200 distinct varieties and thousands of forms.

Several of these have been found to possess extremely valuable qualities such as resistance to diseases, drought, frost, etc. Prior to this the work on potato was confined to the single species, *Solanum tuberosum*, and even the Linnean composition of a species was not known.

As a result of similar expeditions to almost all parts of the world, Russia has made a collection of 29,200 forms of wheat. Amongst these are several wild species and forms immune to diseases. Expeditions to Caucasus, Central Asia and mountains of Azerbaijan have also led to the discovery of wild species of apples resistant to frost and woolly aphis, wild pears resistant to diseases, drought and cold. Discoveries of similar wild plants have been made in respect of a whole series of other crop plants which are being utilized not only for the improvement of cultivated plants but also for the production of entirely new species of crop plants resistant to diseases and unfavourable climatic conditions.

The researches of Papov have shown that side by side with *Amygdalus communis*, the wild progenitor of the cultivated almond, there appear related wild species *A. Korshinskyi*, *A. bucharica*, etc., in their centre of origin just as with *Pryrus communis*, the progenitor of the cultivated pear, there occur *P. Boisseriana*, *P. Korshinskyi*, etc. With the help of cytological studies the origin of cultivated species from the wild species has been traced. Sorokina by crossing wild species of *Aegilops triuncialis* with *Triticum dicoccoides* has synthesized the wheat species *Triticum persicum* resistant to rust and mildew. On the other hand, Eghis, Kostoff and Clausen have produced several triple hybrids experimentally by crossing three species differing in their multiples of the basic chromosome number. The success of Karpechenko and others in the production of intergeneric hybrids and the conquest of sterility by duplication of chromosomes with colchicine have opened up a colossal possibility in the improvement of crop plants which may yet be realized by the combined study of genetics and cytology.

In the U.S.A. there has been a conscious shift in the plant introduction objectives from the discovery of improved varieties of plants to a search for wild forms of cultivated plants. When the cantaloupe industry in that country was threatened with destruction by powdery mildew, it was a wild Indian musk-melon, most unpromising and over-looked as a crop but possessing the single character of being resistant to the disease that saved the industry from ruin. Similarly, the sugarcane industries of Java and Lousiana were saved from the destruction of *Sereh* and mosaic diseases respectively through the incorporation of wild genes from *Saccharum spontaneum*, found growing throughout India in places liable to severe drought and flooding. Even in India it was found as early as 1912 that intraspecific hybridization within the cultivated species of sugarcane did not result in the production of types resistant to diseases and adverse climatic conditions. But interspecific hybridization between the wild species *S. spontaneum* (Coimbatore form) and *S. officinarum* resulted in the production of greatly improved types of canes resistant to diseases and drought. The value of wild species and wild forms as genetical material for a fight against the ever-increasing diseases and adverse soil and climatic conditions have been recognized in almost all the advanced countries. When the work of the Russian Geneticists was known the Swedish Plant Breeding Institute sent an expedition to S. America for the collection of frost resistant forms of potato. Quite recently the Governments of the U.S.A. and Australia are scouring the world in search of wild forms of crop plants with the object of introducing resistance in their cultivated types.

Recent cytogenetical studies have disclosed the fact that most of our crop plants originated from wild forms. In the course of evolution, the cultivated plants having been subjected for centuries to a process of inbreeding and selection for a very specialized purpose have lost a good number of dominant genes and have greatly changed from their progenitors. Thus we find the defects common to all our cultivated plants are suscepti-

bility to diseases and insect pests, sensitiveness to unfavourable conditions of growth and general loss of vigour. It is now increasingly realized that the wild relatives of cultivated plants maintaining themselves in nature amongst competitors and severe conditions and withstanding the rigours of natural selection must have developed some traits quite different from the cultivated plants. The wild forms are, as a rule, found to be genetically distinct with dominant genes, complex group immunity to diseases, great adaptability to extreme conditions and hardiness. It is specially for these characters that they are chosen as parents in crosses.

The present and the most urgent need in India is to make a systematic and exhaustive collection of wild species and wild relatives of all the cultivated crops from their respective centres of origin and incorporate the wild genes into the existing improved types of crop plants so as to make them immune to diseases, tolerant to adverse climatic conditions and vigorous. Work on interspecific hybridization between cultivated species and the wild species is therefore likely to play the most important rôle for the synthetic creation of polyploid forms of crop plants with the above qualities and in this, wild genes hold the key in the building up of future agriculture.

From the discussions that had already taken place, it is clear that we will have to explore wild forms for breeding purposes. So far, very few explorations for search of wild forms have been carried out. This cannot be done unless and until we have Provincial Botanical Surveys which will organize provincial excursions to make provincial and regional floras and herbaria. This work is meant to be done by the new society called 'Indian Ecological Society' which will hold its opening meeting this week. This society can be utilized in the matter of exploration of wild forms of cultivated forms.

While the importance and urgency of the matter were realized by every one present at the meeting, a considerable amount of discussion took place on problems like how the work is to be carried out, what to do with the material collected, what arrangements are to be made to maintain the collections, etc. Ultimately, the meeting unanimously passed the following two resolutions:—

Resolved :

(1) That early and efficient steps be taken through the Imperial Council of Agricultural Research and similar bodies as well as through our Universities to collect together and describe in all aspects the wild species of plants related to the main agricultural crops of the country.

(2) That a Committee consisting of Messrs. K. Ramiah, Indore, Rao Bahadur T. S. Venkatraman, Coimbatore, Dr. B. P. Pal, New Delhi, and two members selected by the Indian Botanical Society be authorized to work out details in this connection and give effect to the first resolution.

XXVI. SULPHANILAMIDE GROUP OF DRUGS.

(*Sections of Physiology, Chemistry, and Medical and Veterinary Research.*)

DR. B. B. DIKSHIT, Bombay, presided.

1. MR. K. GANAPATHI, Bombay, opened the discussion.

Mr. Ganapathi said that although more than 700 sulphanilamide compounds have been studied and many have been introduced for clinical

trials, those that are outstanding are—sulphanilamide, 2-sulphanil-amidopyridine (sulphapyridine), 2-sulphanilamidothiazole (sulphathiazole) and 2-sulphanilamido-4-methylthiazole (sulphamethylthiazole). In spite of the complexity of the question, some relationship between chemical constitution and chemotherapeutic action, within narrow limits of structural changes, is apparent in this class of compounds (Fourneau, Trefouel *et al.*; Ganapathi). There also appears some sort of specificity in the manifestation of therapeutic action by different compounds in various infections (Rosenthal; Ganapathi; Marshall).

Sulphanilamide possesses irrefutable therapeutic effect in the infections due to—*haemolytic streptococci, meningococci, gonococci, clostridium welchii* and *B. coli*; it also appears to be effective in *Brucella abortus* and *B. proteus* infections; against the *pneumococci* its effect is less striking and against the *staphylococci* far less. Sulphapyridine shows a striking effect against the *pneumococcus* infections in addition to being as good as sulphanilamide in others. Sulphathiazole, synthesized independently and extensively studied at the Haffkine Institute, shows a striking effect in the *streptococcal* and *pneumococcal* infections (Rao and Ganapathi). Its effect in plague infections is outstanding being far superior to sulphapyridine (Sokhey and Dikshit). In staphylococcal infection, it is definitely superior to sulphapyridine (Long and Bliss). It is effective in *P. Knowlesi* infection in monkeys (Dikshit and Ganapathi). The above three drugs possess fairly good therapeutic effect in experimental *E. typhosus* infection in mice but absolutely with no effect in *V. cholera* infection (Rao and Ganapathi). The two virus infections definitely influenced by these drugs are lymphogranuloma venereum and trachoma. Experimental rabies infection in mice and vaccinia virus infection in rabbits appear to be refractory to treatment with these drugs (Rao and Ganapathi). The trypanosomes and the spirochaetes are uninfluenced.

Of the above three compounds, the last is the least toxic. All are absorbed fairly rapidly from the gastrointestinal tract and distributed throughout the body. Part of the drugs gets inactivated by acetylation. They are excreted fairly rapidly, sulphapyridine being the slowest of the lot. In the clinical trials with these drugs, their blood concentrations attained rather than the oral dose should be the criterion. A critical study of the various aspects of the question indicates that in mild infections a concentration of about 3–5 mg. per cent of the free drug in the blood should be maintained while in severe infections at least 5–10 mg. per cent through the course of the infection.

The mechanism of action of the sulphanilamides is much more subtle than that of the simple germicides. The theories that they act by neutralizing the toxins, stimulating phagocytosis or other specific immune defences of the body have not much evidence to back up. Mayer, Schaffer, Fox and others consider the biologically mediated oxidation product of sulphanilamide to be responsible for the therapeutic effect. There is greater support for the theory that the sulphanilamides are primarily bacteriostatic in action rendering the micro-organisms vulnerable to destruction by the immune forces of the body. This bacteriostatic action, in general, is traced to the interference of the drugs with some enzymatic reactions connected with cell nutrition and metabolism of the parasite cells (McIntosh and Whitby; and others). The enzymes thus inactivated have variously been suggested to be the proteolytic enzyme (Lockwood); Catalase (Locke, Mellon *et al.*); the enzymes having glyceral, pyruvate and lactate as their substitutes (MacLeod). The recent interesting researches of Stamp and of Green have culminated in the very significant theory of Woods and Fildes that sulphanilamides act by competing, by virtue of their structural similarity, for an enzyme of some fundamental nutritional importance with its natural substance which is an 'essential metabolite' surmised to be *para*-amino-benzoic acid.

2. Dr. U. P. Basu, Baranagore (Calcutta).

Dr. Basu said that since the announcement of the anti-streptococcal activity of 'prontosil' extensive investigations have been carried out both chemically and pharmacologically to find out a clue to its characteristic mechanism of bacteriostatic and bactericidal action, and it was soon noticed that the parent compound, sulphanilamide, is equally therapeutically active compared to a large series of derivatives already synthesized. The question, whether sulphanilamide is or is not the sole active agent in this new therapy, remains still unsolved, but work has always been in progress to obtain one or other derivatives of the same in the expectation of isolating a more potent drug. It has been definitely established that any alteration in the constitution of its molecule practically annuls the therapeutic activity of the drug. The substitution of the 'amino' hydrogen by quinoline and acridine rings may increase the solubility or lessen toxicity of the product; it is, however, the replacement of the 'amino' hydrogen by suitable substituent that only widens the range of activity of the drug. The toxic manifestations after ingestion of the drug has again led to considerable investigations of biochemical nature, and the results obtained, have been utilized in the proper clinical application of the drug. The phenomenon of acidosis and cyanosis can be easily detected and controlled. A knowledge of the chemical characteristics of the drug or its conjugated product is helpful in preventing any urinary obstruction or even renal calculi. A study on the non-protein nitrogen content of the urine of patients would indicate the influence of the drug in the haemopoietic system. Thus, in any work with this drug therapy chemistry would not only play a part in the synthesis of any potent product but may also help in controlling the side reactions exerted by the drug.

The mode of action and the precise therapeutic limitation still remain a matter of uncertainty, and as a result, chemists have to adopt a blind method and roam in darkness in search for a compound of any clinical importance. Evidences are there to show that oxidation of the drug, or inhibition of some bacterial enzymic reaction is responsible for the bacteriostatic action of this group of drug. Whatever it may be, the problem is to be solved so that the proper group or groups may be attached to the sulphanilamide molecule to render it selective for different bacterial types. An important thing in this work is the organization of collaborative effort between chemists, bacteriologists, pharmacologists and clinicians and an all-round attack on the problem from different angles.

3. Lt.-Col. S. S. Sokhey, I.M.S., Bombay.

Lt.-Col. Sokhey wrote about the very remarkable results he was getting with sulphathiazole in the treatment of plague at Latur, Hyderabad (Deccan).

The first thing to be noticed in the present trial, he said, was that the cases being brought to hospital were of a very severe nature; a much larger number of cases had septicaemia at the time of admission than he had ever noticed before. So far he had treated 55 patients. Twenty-two patients among this group who did not have septicaemia at the time of admission had all survived. Out of the 33 septicaemic cases, 9 were moribund at the time of admission and died within 24 hours of admission; of the remaining 24 cases, 19 had survived. Thus the percentage of recoveries in non-septicaemic cases was 100% and in septicaemic cases 80%. Even if moribund cases were included he got the percentage of survivors in septicaemic cases as 58. It was to be noted that mortality in septicaemic cases with the usual treatment in vogue in hospitals at present is 100%.

During the present trial the dosage was being controlled by the determination of the concentration of the drug in blood from time to

time. An attempt was made to get a concentration of at least 10 mg. per 100 c.c. of blood as rapidly as possible and this concentration was maintained for 3 or 4 days and then the dosage was gradually reduced. It meant giving of something like 4 gm. or 8 tablets of the drug on admission and 8 tablets 4 hours later, followed by 2 to 3 tablets every 4 hours. This dosage was much larger than the one used at Bettiah in another field trial. Colonel Sokhey was not sure whether this very large dose was really needed. He was still attempting to determine an effective but not too large a dose. The question of toxicity was also being carefully studied.

4. Sir Ramnath Chopra *and* Dr. B. Mukerji, Calcutta.

In the absence of Sir Ramnath, Dr. B. Mukerji presented the results of the investigation on the sulphonamide group of drugs undertaken in the School of Tropical Medicine and the Biochemical Standardization Laboratory. The investigations were planned with a view to study the comparative toxicity and therapeutic efficiency, both in laboratory animals and hospital patients, of the more important and commonly used remedies of this series—(i) 'prontosil rubrum' and 'prontosil soluble' among the azo dyes; (ii) sulphanilamide, a non-patented drug sold under a variety of trade names and manufactured by a large number of firms both foreign and Indian; (iii) sulphapyridine and its soluble sodium derivative; and (iv) sulphathiazole, the recently introduced thiazole analogue of sulphapyridine. The experiences gained from this work during the course of the last year and half has been summarized below. In the laboratory, sulphathiazole has been found the least toxic of all the derivatives of this series, a finding which confirms previous work on the subject both at the Squible Research Institute, America and the Haffkine Institute, Bombay.

I. *Bacterial and virus diseases.*

(i) *Cholera* is an important disease from the point of view of India and a large number of epidemic cholera cases were treated with *diseptal B* (p-aminobenzene—sulphonyl—p-amino-benzene-methyl—sulphonamide) in doses of 3 gm. daily for 3-4 days. A control series were treated with fractional doses of calomel. Intravenous saline therapy was administered in all the cases in both the series. The mortality rate in the series treated with diseptal B was 7·9% as against 12·69% in the control series. This compares favourably with the results obtained in the treatment of cholera with bacteriophage.

(ii) *Enteric group.*—Two acute cases and two carriers who were passing large number of organisms in their stools were treated with sulphapyridine in usual doses. No appreciable effect in the number of *Bact. typhosus* in faeces was demonstrable.

(iii) *Meningitis.*—Sulphanilamides (manufactured locally and of foreign origin), sulphapyridine and diamino-diphenyl-sulphone glucoside were employed in the treatment of Meningitis both independently or combined with serotherapy. The majority of the cases belonged to meningococcus Gr. 1, a few were pneumococcal and an occasional one or two cases were tubercular or of the influenzal type. The mortality rate was reduced from 60% in the control series to 32% in the drug-treated series. The combined drug plus serotherapy gave better results (Chopra *et al.*, *I.M. Gaz.*, 1940). The best results were obtained with sulphapyridine. In pneumococcal meningitis, chemotherapy with any of the sulphonamide preparations was unsatisfactory.

(iv) *B. coli cystitis.*—Three patients were treated with sulphapyridine (3 gm. for 5 days), of which two cases showed remarkable improvement. The third case however relapsed after a month.

(v) *Smallpox.*—The effects of sulphapyridine and prontosil were tested in cases of hemorrhagic smallpox with no apparent success.

(vi) *Hydrophobia.*—In one case of hydrophobia, in which antirabic vaccine was administered previously, sulphapyridine soluble was administered intrathecally in Normal Saline. The only noticeable effect was slowing in the progress of the disease but death ensued in the ordinary course.

II. *Protozoal diseases.*

(i) *Malaria.*—'Prontosil' and 'Soluseptasine' have been shown to possess a definite action on *Plasmodium Knowlesi* in experimental infections in monkeys when administered in comparatively large doses. Sulphapyridine is capable of destroying the monkey plasmodium in doses much less than the optimum therapeutic dose ordinarily prescribed. In human malaria also, sulphapyridine showed mild anti-malarial properties.

(ii) *Leishmaniasis.*—The sulphonamides do not show any remarkable curative properties in kala-azar.

(iii) *Amoebiasis.*—In chronic amoebic infections, sulphonamide derivatives have been tried in the hope of finding something better than the existing remedies in chronic cases. The results are poor.

III. *Helminthic diseases.*

Filariasis is widely distributed in the tropics and it is now well known that secondary streptococcal infection plays an important part in the production of acute lymphangitis in cases of this infection. No drug has been found so far which can destroy the filaria in the body but 'prontosil' and its derivatives brought about rapid cure in surgical complications of filariasis where no secondary bacterial infection could be discovered.

From the experimental and clinical work with some of the more commonly employed sulphonamide derivatives, it is now possible to state that these drugs are of definite value in *malaria*, *meningitis*, possibly *cholera*, *plague* and *B. coli cystitis*. In conditions where associated infection with streptococci is existing, e.g., filariasis, influenza, measles, etc., they undoubtedly produce beneficial effects.

Toxic manifestations with these drugs undoubtedly occur but these are comparatively rare in therapeutic doses. Moderate cyanosis is not usually an alarming symptom. The sulphonamides undoubtedly affect the hemopoeitic system and the sulphur in its molecule does combine with hemoglobin but unless the dosage is pushed to extremes, these difficulties are not of sufficient importance from the practitioner's point of view. Laborious experimental work is needed both in the laboratory and in the clinic to bring out the extent of the prâctical value and application of these derivatives in tropical diseases. The tendency, often seen, of making pronouncements on the efficacy or otherwise of a particular compound or derivative without adequate chemotherapeutic and clinical trials is to be strongly deprecated.

5. DR. B. A. PATHAK, Benares.

The speaker put forward the general practitioners' points of view regarding the sulphanilamide drug. He remarked that these drugs probably had no pharmacodynamic action; they were evenly distributed in the body and rapidly eliminated. They produced their effect only when the organisms were actively multiplying in the blood or in the tissues. He briefly referred to the combination of the drug and serum therapy and said that the general practitioner found it difficult to determine the blood concentration of the drugs or type the invading

organisms and suggested that a clear knowledge of the dangers of this drug and the maximum safe dose limit would be the only guides on which he could base his therapy. He also referred to the problems of idiosyncrasy and the pathogens getting drug-fast. After mentioning the local and prophylactic uses of the drug he gave a warning about the indiscriminate use of these new drugs and mentioned how some quacks were misusing them.

6. Dr. B B. Ray, Calcutta.

In connection with the treatment of cases of cholera with sulphonamide group of drugs referred to by Sir R. N. Chopra and Dr. B. Mukerji, an important question arises which needs careful consideration. Cholera is a disease characterized by oliguria and in extreme cases, anuria. Sulphonamides are excreted almost wholly by the kidneys. Is it not likely that in cholera there will be an accumulation of the drug in the blood to a degree which might give rise to serious complications? Again, it has been contended that sulphonamide group of drugs are prone to bring about an acidosis and from this consideration, the use of sodium bicarbonate along with sulphonamide therapy has often been advocated. In cholera, there is already a certain degree of acidosis and it seems reasonable therefore to avoid administering a remedy which is apt to aggravate such a condition. In a large number of cases of cholera, simple treatment with saline without any drug gives a cure rate of as much as 70%. Therefore, in cases treated with both saline and sulphonamides, it is difficult to ascribe any remedial importance to sulphonamide unless very careful controls are maintained. In treating cholera, therefore, the workers should keep these contra-indications in mind.

7. Dr. B. B. Dikshit, Bombay.

In summarizing the discussion Dr. B. B. Dikshit said that co-operation between chemists and pharmacologists has proved extremely valuable in the field of chemotherapy and hoped that such a co-operation will result in many more new advances in the treatment of human sufferings. He paid a tribute to the zeal of Indian chemists who are synthesizing new compounds almost every day and pointed out that pharmacologists available at the moment in this country to test these new compounds are very very few in number. Moreover, a pharmacologist has to undertake a large number of careful investigations before pronouncing a drug as suitable for clinical trials. A proper organization to study chemotherapeutic agents should have at least 10 pharmacologists for every one chemist, and this too, in his opinion, was a very moderate estimate. The proportion at present prevalent in this country is just the reverse or even less. A very large number of useful preparations have therefore to await pharmacological investigation for a long time. He further pointed out that pharmacologists have to keep in mind the important factor of biological variation and warned against conclusions drawn by some workers on experiments conducted on a few animals. He briefly referred to the team work organized by Col. Sokhey at the Haffkine Institute and said that this team work was working very satisfactorily.

XXVII. THE PSYCHOLOGICAL FACTORS IN ADULT EDUCATION.

(*Section of Psychology.*)

1. DR. N. N. SEN-GUPTA, Lucknow.

I. *Some of the Psychological Problems in Adult Education.*

(i) The existence of a well-formed mental set comprising organized interests, ideas, scheme of values and outlooks that reject new material not consistent with them.

These resist, for instance, the mechanical aspect of learning such as spelling, writing or simple calculations of arithmetic. They also resist the appeal by means of pictorial presentation and by the arousal of emulation.

(ii) The presence in adults of a tendency to seek a concrete meaning in everything.

This resists the introduction of much of formal training.

(iii) Varying phases of the curve of growth and different rates of growth in adult.

These make the creation of a compact pupil-group difficult. Consequently, the teacher cannot treat the class as a unit but as a collection. Teaching has to be in the form of individual appeals.

(iv) Diminished values of teacher's personality.

Experience gives adults a value scale along which individuals are measured. To the child, the teacher appears with almost paternal authority. To the adult he is a wage-earner whose value can be estimated along an economic scale.

(v) The existence of a psychic tendency to be critical and to be passive.

The first of these arises on account of diminished suggestibility. The latter arises from lack of interest.

(vi) The difficulty of appeal to reward and punishment.

This stands in the way of ensuring study and correction.

(vii) A lowered valuation of the educative process in comparison to the actual life.

This leads to a certain levity in regard to the educational efforts.

II. *Psychological Analysis.*

The difficulties arise on account of the following:—

(i) Accentuation of individual differences due to the varied personal history of individuals.
(ii) Lowered suggestibility.
(iii) Sense of the concrete.
(iv) Diminished importance of the
  (*a*) teacher, and
  (*b*) educative process.

III. *Psychologist's Approach to a Solution.*

(i) Creation of a group spirit:—
  (*a*) it diminishes individual differences;
  (*b*) it increases suggestibility;

(*c*) it raises the mind on the hallucinatory plane and diminishes the sense of the concrete;
(*d*) leads to regression towards the childhood level.

(ii) This can be done in the contest of:
(*a*) religious ideas;
(*b*) social, economic and political ideas.

(iii) These would give (*a*) the teacher the sam paternal status as in childhood.
(*b*) Increase the importance of the educative process.

IV. *Conclusion.*

(1) Historically the schemes of adult education have been successful in the context of an ideology. The reason is in conformity with the psychological analysis.

(2) They are also successful in the setting of an economic life as in a factory where educational success or failure means reward or punishment.

(3) Adult education in India, thus, should utilize (*a*) the *ideological groups*, and (*b*) the localized economic organizations such as factories.

(4) The former would comprise the religious groups such as leagues and sabhas, political groups such as local congress and other party organizations, temples and mosques. The latter should comprise factories and local trade unions. These should be induced to take up adult education as an essential part of their programme.

(5) Education would receive in this manner an ideological sanction, political and religious.

(6) In the case of factories, a return should be demanded along with other factory returns about arrangements for workers' training, the increase in the number of literate and about the granting of additional privileges, say in the form of extra leave to those who complete a scheme of adult education.

(7) The real difficulty arises in the case of the large scattered rural population that does not usually come within the orbit of any of these organizations. In these cases a scheme of short-term schooling conducted by a peripatetic group of teachers associated with a further scheme of reward for those who complete education may meet the need. Some State privilege such as lowered cess or tax, a promise of free training for children, or free gift of some kind of agricultural perquisite may be a sufficient stimulus. Reward that fits in with the concrete setting of life is the only possible motive to which appeal can be made.

(8) A combined effort through the co-operation, and economic reward ensured by legislation are the only methods that can prove successful.

2. MR. H. P. MAITI, Calcutta.

1. Adult education and adult literacy. Real aim of adult education in India at present.

2. Limitations of adult learning arising from the psychology of the adult. Adults and adults.

3. Application of psychological analysis of the adult mind for—
(1) determination of contents of adult education,
(2) motivation of adult learning,
(3) technique of teaching the adult,
(4) selection and training of teacher quality.

4. A short historical review. Need of experiments in educational psychology of the adult.

3. Dr. Indra Sen, Delhi.

I. Adult education in the strict practical sense is identified with the spread of literacy among the illiterate adults. But adult education, as a scientific concept, should mean education at the adult stage, whether in the form of continuation of education of the already educated or fresh education of the uneducated (illiterate). Further it cannot be taken as identical with literacy since education in the proper sense of the term is a process of cultural upliftment of the whole man.

II. Means of adult education of former days in this country. What led to the cultural fall of the villager? The modern methods, which are being employed and which may be employed more effectively in the cause of adult education.

III. A characterization of the adult mind. The relative unreactiveness of the mind of the illiterate adult, its unresponsiveness to the incentive of progress and change, the chief difficulty in the way of adult education. The cause of it. A few necessary psychological considerations for the literary worker.

IV. It is now well known that in a school or college the atmosphere of the institution educates more effectively than the class-room lecture. Exactly in the same manner for adult education, in the last sense of the term is a cultural regeneration of the masses, an atmosphere of hope, responsibility and self-dependence will achieve what no amount of night schools or educational pictures or radio or rural programmes can. Moral depression existing in the country is the worst handicap to adult education.

V. A psychological examination of the various methods of teaching to read and a few practical suggestions for the spread of adult education.

4. Miss R. Ure, Jullundur.

We speak here not of a vision or a dream, but of something that *exists*. Adult education is now an integral part of modern social architecture in every land. Sometimes this recent addition to a planned human economy is built on a cheap and flimsy fashion. It is to forestall that mistake in India and to ensure a solid foundation that we are here considering the psychological factors involved. Since I bring as my contribution three years' basic experience of the literacy campaign in the Punjab, I speak from the literacy standpoint. To be sure, the literacy campaign is only a beginning of the wide field of adult education, but the psychological principles remain the same. Moreover, literacy is a prerequisite to all other adult education, a *sine qua non*; for without books education is spoon-fed; we must have a man able to ferret out for himself, to weigh, to balance, to distinguish. He must not be dependent on teachers, whether one or many, for all however good have a bias and a prejudice; he must have personal access to the world of written wisdom. Further, literacy is not just a first and painful step to knowledge; it is in itself a liberator of personality and therefore qualifies as in itself true education.

The psychological factors are two-fold; root and fruit. The laws of approach are tremendously important; thanks to Dr. Laubach they are widely known, but they are not always followed; the curve of probability of success is in strict ratio to adherence to these laws. The widespread apathy toward education which we deplore is partly the fault of our type of education, and partly due to a lack of the social sense which impels folk to become teachers of the under-privileged. For it costs to undertake this work, costs more than most people are willing to pay. But that it is worth the price is amply evident. Take for example the penniless peasant woman from an isolated village who came to a city summer school with the shining determination to learn to read, and her recent report that though she could not go ahead she was daily reading at home each page that she had learned and that in two more

summer schools she counted on finishing her primer. Pathetic?—glorious. Or the illiterate sweeper who caused a domestic crisis because the cook was the only one who could forge his name on a savings account and the cook was leaving town; and who a few months later was proudly putting his own signature on his master's bank communications. Teaching adults is worth any price.

In discussing the method to be followed let us first consider the laws of approach as they underlie the preparation of teaching materials. The cardinal principle is to meet the adult where he is. Thus with regard to language it is essential that the language employed be that in which the pupil thinks. All beginning books must be based on scientific vocabulary studies, such as that of spoken and written Punjabi now completed by the Forman Christian College, Lahore. It has been found that there is a quick transfer from the local dialect to literary language in the same script, but it cannot be too strongly stressed that for the initial stages a man's own thought-vocabulary must be used.

Secondly, since the pupil is a thinking and experienced individual, as sane and as wise as the teacher, all teaching materials must have both meaning and interest for the adult. This rules out alphabetical methods; it rules out nonsense syllables; it rules out the use of children's stories. It demands a whole new series of books, scientifically constructed, first to capture the imagination of the adult from the very first page, as for example the character problem of 'Ilm di Kunji' has challenged the thought of readers, and second, in order to be sound from the educational standpoint, to meet unobtrusively the following needs: slow introduction of new syllables, according to careful word counts, repetition of old syllables in both old and new combinations, and gradually letter drill, by the use of flash cards or picture-word-syllable charts, etc. But such drill should be always in moderation and as unconscious as possible. The point I am trying to make is that for adult education the tools must be correct. This is a new field in practically the whole country, offering a life-work, not just an avocation but a vocation, for many. The need for new and fascinating books on all subjects is inexhaustible, since whole libraries are to be prepared. The aim is to put a library in every community, rural and urban, where there is even one literate, to prevent lapse and to woo to increased knowledge. Nor is this aim impossible. The Punjab has evolved a scheme for circulating libraries of sixty booklets housed in a remodelled kerosene tin, for a total expenditure of less than ten rupees. Surely every community has one philanthropist who would underwrite and sponsor this public service.

More important even than the materials is the actual teaching process, with its twin factors of the attracting and holding of attention and the integrating of emotion and will to the learning process. Here the teacher must be a genius. Many have found it invaluable to hold training conferences for those intending to teach, where the principles and the vision may be grasped. The teacher must have the right attitude toward the pupil; he must respect him, honestly, as he respects his equals or his superiors, and beyond that he must have, if he is to be successful, a genuine love for his pupil, really felt in his heart and shown in all his contacts. This will eventuate in the right tone of voice, that tone used in conversation with one's friends, and in the right attitude toward mistakes, for he will never allow any discouragement, and in the right attitude toward success, for he will be thrilled over each evidence of achievement. The true teacher will be the friend of his pupil. It is impossible to overemphasize the importance of confidence on the part of the pupil, and of an uninterrupted feeling of progress. A man who down-heartedly reported that he had tried everything but his wife simply could not learn, was observed by a supervisor; at her first mistake he called her an idiot, and after a few more errors he hit her. Compare that atmosphere with that created by the teacher who told his pupil that he needed help in teaching and had chosen this particular individual because he

was bright and would soon be able to instruct others. The confident pupil strides ahead.

A right attitude toward the lesson hour is also important. It will be far from formal; it will be a very good time, with lots of fun and plenty of laughter. Educational psychology teaches that when learning is a pleasurable experience it is more rapid and far more apt to be retained; but experiment teaches that unless it is accompanied with pleasure adult education just does not exist, for the pupil will disappear. Further, the lesson hour will be a drawing out of the pupil, 'eliciting rather than telling', a building upon the powers of observation already acquired. For this reason mass instruction is not feasible; the varying backgrounds of the group too seriously 'fractionize' the attention of the teacher and retard the individuals. At the literacy stage all adult education should be in classes of one only, for a very brief concentrated period. Another requirement is that there be smooth progress, no hitches, no delays, no unnecessary repetitions, and yet thoroughness in each detail. Plateaus should be recognized as normal rather than disturbing elements. The importance of teaching writing along with reading should be mentioned, for writing enlists the aid of the visual, tactile and muscular sensations. Part of every lesson should be that the pupil teach another, for this provides unconscious review with a purpose, meeting the requirements of repetition and spaced learning with an extrovert challenge.

How then shall we relate emotion and will so that attention may be permanent and effective? For motivation is the largest single problem in this movement. Satisfaction is both immediate and prospective. Immediate satisfaction is obtained by the adult in class, through the pleasure and confidence and sense of achievement engendered. It is also obtained through the social approval of the community, of which intangible it is well to give concrete evidences. Recognition from the group is symbolized, for example, by the growing custom of awarding badges to the new literate who can pass a simple test of reading an easy passage and of signing his own name, and to his proud teacher; or by the placing of markers on the road to villages which have become one hundred per cent literate, as in Gakhar, Punjab, or the putting of signs on the doors of village houses to indicate the number of readers in the family and to praise a wholly literate household. For the hopes of prospective satisfaction I refer you to the list of motives compiled by the South Indian Adult Education Association, namely:—

(*a*) Practical motives: to read and write letters; to sign one's name; to find better methods of cultivation, pasturage, cottage industries, marketing, child-care and health; to avoid trickery by being able to read contracts and mortgages; to earn more money, spend more wisely and get free of debt.

(*b*) Cultural attractions: to read stories, songs, and dramas about kings, saints and heroes; to read newspapers and periodicals and know the amazing events taking place in India and the rest of the world; to gain a heightened sense of self-respect.

(*c*) Patriotic incentives: to obtain the franchise and vote intelligently; to work for India by helping to make every one literate.

(*d*) Religious motives: to read inspiring religious books; to take intelligent part in worshipping God.

All these ambitions need to be implanted in public opinion, for they are the grafting of acquired interests upon those which are inborn.

Prior to pupil motivation is teacher motivation. How can India be roused so that every one will share in the great service of adult education? A pony man was being taught by his summer's employers; he wept when they left and his lessons stopped, for though the State had stationed a paid teacher for adults in his circuit of villages, he said it was impossible

to have lessons without offering bribes. A curse upon the pay system for such a service as this. There are more worthy motives. In a certain jail there were very fortunately two ex-masters among the convicts; when they faithfully and successfully taught those incarcerated with them they were granted remission of sentence and reinstatement in their positions. That is a powerful motive, but scarcely widespread! But there are other personal values to be gained, not least of which is the gain to one's own personality in giving time and energy and love to those less privileged. Those who have made an adult literate recognize it for an experience they would not have missed. Then there is the motherland motive, that our nation shall not be exploited by other nations which are more advanced, that our nation shall not be behind other nations in any way, that our nation shall be truly free, for freedom is of the mind and spirit. Strongest of all is the religious motive, responsible for much of what is now being done; this has its dangers, but it is potentially capable of sublimation if animated by high ideals. An excerpt from the letter of a literacy demonstrator reads: 'When we work amongst illiterates we have to get mixed up into them without showing thereby any distinction or a sign of hatred. I have been doing all this which caused me to get a disease which is very common in the central Punjab and that is "itch"'. I submit that when our college graduates and leading men become willing to mingle as helpers and friends with all classes and to run cheerfully the risks of infection and other evils involved in order to service, a glorious day will have dawned in India.

Possibly more interesting are the psychological results, in which we see not the mechanics but the importance of the movement. For those who are psychologists one challenging thing is the realization that the literacy campaign is a laboratory, a new place to observe the workings of the mind. For the adult mind is not the child's mind, and we are as yet far from knowing all there is to know concerning it. It should be possible to make many valuable discoveries in this wide and scientific effort to eradicate illiteracy.

And far beyond the psychological interest is our common humanity. I submit that the literacy campaign is a recreative influence, which materially changes the quality of living. Study its effect on personal psychology. Consider the member of a school's menial staff, who was moved to tears the first time she was able to put her own signature on the receipt for her salary. It was my privilege to meet in one of the State capitals a man who had three months previously been entirely illiterate and who was when I met him teaching in the school through whose efforts he had been taught. When the headmaster offered him a salary for the valuable work he was doing he emphatically refused, saying, 'Take money from *you*? Never! You've made a man of me. Now I must serve others'. This thing changes lives and outlooks. Study its effect on the psychology of the home. The teacher left before Karmi had made much more than an enthusiastic start on learning to read, but her educated husband took up the task there and now they both proudly rejoice over their joint success. On the other hand, Ishar Das and his wife began at the same level of ignorance, and had all their lessons together, each vying with and helping the other, and now they regularly borrow books to read aloud to each other. In many other cases like those we glimpse new possibilities for mutual respect and co-operation within the home. Consider the effect on social psychology. When, as recently happened, one finds the coolies in a railway station each clutching a primer and studying it assiduously between trains and learns that a young graduate comes daily at the request of the authorities to give two hours of lessons, one knows that a leaven is at work in society, influencing both the taught and the teachers and hinting at a new order to be created. Powerful indeed are those interests which transcend communal, national, racial lines, and such is adult education in India proving itself to be.

Psychology does well to take seriously a field so rich with opportunities for its own study and for the enrichment of humanity. Let it put the best it has into this movement from the start. Let it underwrite the needs of the campaign: the need of an adequate reason for being, the need for popularity, for an impelling love, for endurance, and for vision of the future. And let it reap for itself new knowledge, and for the world millions of enlightened personalities.

Synopsis.

Adult education to be successful must be psychologically sound. The literacy campaign is essentially the first step, to liberate both from a sense of inferiority and from biassed teaching. It is a difficult task but worth the price.

In preparation of teaching materials two laws are outstanding: the language used should be that in which the pupil thinks; and from the very beginning all material must have meaning and interest for the adult. The tools are to be both psychologically and educationally correct, from first primers through the great mass of literature and libraries which are to be provided.

In the teaching process the teacher must instil confidence by his own attitude of respect and appreciation, must ensure that the lesson be pleasurable, and endeavor to have the pupil also teach. Incentives are immediate satisfaction in pleasure, and social approval indicated by badges, markers, etc., and prospective satisfaction in the practical, religious, etc., values to be obtained. Teachers may be motivated by personal, national and religious goals.

The literacy campaign is a laboratory for new discoveries concerning the working of the adult mind. It is also a recreative influence, with profound effects upon the psychology of the individual, of the home, and of society. Psychologists should recognize its importance toward the building of a better world.

5. MR. H. B. RICHARDSON, Indore.

A. The psychology of the adult with regard to education.

1. Past experience—its formative value.
2. Idea of education as part of childhood conservatism and lethargy of age.
3. Unwillingness to accept education for its own sake. Need of emphasising economic aspects.
4. Education as synonymous with academic study.
5. Idea of education as something apart from life.

B. The adult at school.

1. The uneducated adult as a combination of childlike and aged qualities.
   Need to attract him through pretty, strange and artistic means.
   Need to overcome conservatism and prejudice.
2. The experienced adult is, to some extent, a natural scientist.
   Ability to compare and contrast and carry on.
   Simple inductive and deductive reasoning.
   Hence need of adapting education to this end.

6. MR. JAGDISH SINGH, Lahore.

Literature for adults.

The past efforts for adult literacy have suffered from a great setback, viz., lapsing back into illiteracy of those adults who were made literate

within a few weeks. One of the chief causes of this was the lack of suitable literature. Adult literature may be divided into two broad divisions—(*a*) the beginning lessons, and (*b*) the follow-up material. Both are of equal importance, the latter of greater importance. Suitably graded literature is most essential for the needs of adult literates. The question of language is very closely linked with literature. Both the beginning lessons and the follow-up material should be produced in the spoken language of the illiterate adults whom we want to make literate. The great need of a basic vocabulary of the spoken language and its technique. The work done in Hindi and Panjabi along these lines and the technique followed. Some specimens of the beginning lessons and the follow-up literature produced along these lines.

7. Mr. N. S. N. Sastry, Mysore.

The subject can be discussed from two points of view, i.e. (1) from the point of view of the adult to be educated, and (2) from the point of view of the educator.

The value of adult education should be assessed from the point of view of its capacity to make the educant a better citizen than he has been till now. His character has been formed and he comes with certain habits and prejudices. Thus education cannot help him much in these directions.

One of the primary incentives for the adult to desire education is the desire for superiority to fight the inferiority feeling he has already developed. The incentive should be exploited by the educator. This consideration should prevail in the selection of materials and means. A large measure of success in adult education depends upon the correct exploitation of this incentive. Next, there is the utilitarian motive in the educant desiring to use his equipment for bettering his social and economic status. A due consideration should be given to this also. Often, failures in adult education are due to ignoring this desire on the part of the educant.

There is a certain amount of fear and suspicion on the part of the adults to be educated. It is no easy matter to win the confidence of the pupils in an adult class. Positive proof that the efforts of the educator are only from a desire for service, should often be forth coming. Hence it is not every one who can be an educator of adults.

Naturally, the methods of adult education differ from the ordinary school room procedure. The educant possesses already a certain stock of knowledge. He has developed certain habits and prejudices. He is not easily persuaded to do much of manual work and 'drilling'. Sometimes these factors are handicaps and might easily discourage the pupils. There must be copious use of the visual method in the cinema, radio and magic lantern talks.

The educant has a systemized character already. The education imparted now rarely succeeds in influencing his character. Hence the content of education must suit his adult needs.

Finally, there is always the danger of relapsing. Continuation classes can act as a guarantee against such relapses.

XXVIII. CONFLICT AND SOCIAL BEHAVIOUR.

(*Sections of Psychology and Anthropology.*)

DR I. LATIF, Lahore, presided.

1. PROF. K. P. CHATTOPADHYAY, Calcutta.

The speaker first discussed the mechanism whereby conformity to a norm of behaviour is secured in society. The causes of conflict internal and external were then stated. Examples were given from Trobriand island of a conflict between biological knowledge and the social and economic structure. The obvious facts were denied as they were associated with extremely unpleasant contents affecting the society. A study of culture contact in Solomon Islands was then made. It was shown how a conflict was avoided by conditioning. Finally, the different reaction of Hindu society in different parts of India to Islam was discussed from the standpoint of culture conflict. The speaker came to the conclusion that discord in social behaviour is eliminated either by (*a*) social suppression, or (*b*) conditioning. New myths are also created where found necessary to harmonize the discordant factors with the older traditions.

2. DR. N. N. SEN-GUPTA, Lucknow.

I. *Setting of the Issue.*

I take the problem to connote how far social behaviour from its very nature implicates conflict between the constituents out of which the behaviour-pattern is built. The title may, also, suggest that social behaviour is largely a product of what nowadays are described as *social forces*. Both of these ideas require that the concept of social behaviour itself should be analyzed.

II. *Social Behaviour : its Meanings.*

(i) It may mean any behaviour which is modified by the influence of other individuals of the same species or by the *group* of such individuals. Any behaviour of an adult would be social behaviour in this sense. It is, therefore, too wide a meaning.

(ii) It may signify any behaviour that takes place in the context of the idea of the group or of traditions, customs and *mores*, that have their being in the medium of group life. This, also, gives the term too large a connotation. For, all behaviour of adults is of this character.

(iii) It may signify a type of behaviour that is directed to other fellow beings, actual or imaginary. For instance, sex-behaviour. This raises the question whether behaviour has an unconscious social direction. Social and non-social types of behaviour are, thus, classified on the basis of unconscious factors. Discrimination of social behaviour becomes a matter of difficult analysis.

(iv) It may mean a type of behaviour that arises out of social impulses and emotions. For example, self-assertion, submission, emulation or jealousy. These impulses assume impersonal forms through sublimation and other mechanisms. Hence, detection of social from non-social behaviour becomes a matter of close analysis here as in the other cases.

(v) It may mean what I have called in Social Psychology, reciprocal response. This is accompanied by feelings that arise out of the organic basis implicated in the reciprocal response. These are projected to the act, the self or the object. In the last case, when the object is a fellow being, actual or imagined, the behaviour is social.

III. *Psychological Character of Social Behaviour.*

(i) The preceding analysis of social behaviour attempts to bring out its character as a response-pattern. It is, therefore, not proposed to define social behaviour in terms of *motive* or *object*.

(ii) Both of these types of analysis involve what I consider to be fallacious assumptions. There are various levels of motive revealed in the course of analysis. What may appear at one stage as social may turn out on deeper analysis to be a pure ego-motive. The definition of behaviour in terms of the object to which it is directed commits what James calls stimulus error.

(iii) Social behaviour, then, must be defined in terms of the phenomenal character of the response-pattern. Judged from this point of view, social behaviour pattern possesses the following features:—

(*a*) At each moment social behaviour is a response-pattern and not a linear, single-direction response.

(*b*) At each moment the constituents undergo a rearrangement correlatively with the changes of the stimulus object.

(*c*) Social behaviour-patterns are of three types:

(1) Some of these exhibit the goal-gradient character.
(2) A second group exhibits persistence.
(3) A third group exhibits succession and continuity.

(*d*) These patterns by virtue of their motile character are associated with organic sensation and emotions.

(*e*) In this way, they gradually incorporate in them the hormic urges. It is *not* true to say that social behaviour is instinctive at its base. It is true to say that social response-patterns gradually permit instincts to participate in them. E.g. Response-patterns required in military life are gradually infused with instincts.

IV. *Consequences of the above Analysis.*

(i) Social behaviour (*a*) at every stage has to combat inertia of the body and pre-existing response-patterns. (*b*) It has also to be *plastic* enough to permit the advent of new patterns in successive stages. (*c*) It has also to overcome the tendency to stereotyping.

Hence, social behaviour is perpetually presenting a conflict situation.

(ii) Social behaviour, again, has to *integrate* into a new pattern the past behaviour tendencies, whether inherited or acquired. This, too means the seed of conflict.

(iii) Social behaviour, again, has to strike a balance between the behaviour-patterns of various social foci. Here, again, there is the problem of conflict.

V. *Conclusion.*

Social life of man is said to bring out his best. This is true because it exhibits his capacity to integration of many divergent action-tendencies.

Such motor integration necessarily implicates a high degree of mental capacity. When the mental capacities are low, social behaviour is either stereotyped or in a state of chaos. A high degree of spontaneity of social behaviour implicates a high degree of mental alertness and plasticity.

3. MR. K. C. MUKHERJI, Dacca.

Modern life is very complex. It is also very artificial and is seriously hampered by an accumulation of conflicts. These conflicts are produced in contact with environments which are in conflict with our native behaviour tendencies and may be observed in almost all relations of life. So occasions for conflicts and the conflicts themselves are legion. The strain due to a conflict is distressing. So social disapproval is perhaps the strongest factor in generating conflicts. Sex conflicts are unquestionably very numerous and disruptive in the lives of large numbers of people. Social disapproval for unconventional conduct is also very strong here. But the theory of the sexual basis of all conflicts seems to be exaggerated. Deliberate lying often becomes a method of resolving the conflict by consciously avoiding its consequences. In this respect it is a sort of therapeutic measure—however, not desirable in itself or socially.

4. MR. H. P. MAITI, Calcutta.

There has been hitherto a fundamental difference in outlook between Psychology and Anthropology as regards the scientific study of cultural problems. One proceeds mainly from the standpoint of the individual mind and the other from that of the group. One places more stress on the internal and the other on the external factors. Yet the distinction between the individual and the social is not one of principles or causes but one of levels of operation of the same fundamental principles of human nature. Hence we may expect parallels in important manifestations in individual life and in those of social life.

Conflict of demands and tendencies in individual life, as studied by Psycho-analysis, gives rise to certain types of developments that may be highly interesting from the anthropological point of view. As the result of the conflict we may have successful adaptation or sublimation, or relapse into an earlier form of behaviour or regression, or compromise between a higher and a lower demand or neuroses, or mere juxtaposition of mutually inconsistent traits or dissociation, with the universal tendency of rationalization trying to give support to each one of these processes. Ordinary observation leads one to believe that when one cultural group comes in active contact with a different cultural group and a state of active conflict between cultural demands ensues, social developments take place on the same general lines as are found in the case of the individual. How far differentiation of cultural sub-groups and development of new traits may illustrate this correspondence of principles and types between social and individual life should be worked out scientifically.

5. DR. INDRA SEN, Delhi.

Dr. N. N. Sen-Gupta is right in affirming that we must analyze social behaviour to its fundamentals. But I would accept Prof. Chattopadhyay's approach of taking conflict as implying conflict between social and cultural units.

India's history affords a fine study of cultural contacts, conflicts and adjustments. The relations of the Hindus and Muslims above all is a most challenging problem for the cultural anthropologist as much as for the social psychologist. How is it that the flimsiest of rumour at times succeeds in inflaming the communal passions on both sides. I venture

to suggest that the social behaviour under such circumstances is neurotic and therefore indefinitely pre-supposes repressions and inhibitions on either side. An important reason, why pacts, resolutions and even sincere intentions for unity fail, is that the repressions harbouring fears and mistrust for each other are never recognized and treated in a psychological manner. A psychological abreaction of the repressed emotions is a pre-condition of building up between the communities a positive attitude of amity. But how is this abreaction to be afforded is a question of serious practical difficulty. It may be a presumptuous thought, but I feel that we will have to draw up a new history of the country, which will trace the development of our emotions with regard to each other through the several centuries of our common living in the country. Such a history, involving as it should a frank and sincere recognition of the emotional attitudes of our past relations, a confession of our respective sins as it were, may afford a discharge of the same and thus free the social mind of its inhibitions, which act like secret breaks upon all efforts of communal unity.

The above is, no doubt, a bold hypothesis, but it does not seem to lack convincingness altogether.

(For a fuller statement of the view the reader may be referred to my paper entitled 'Psychology for Communal Amity' published in the Indian Journal of Education, 1940.)

6. Mr. N. K. Bose, Calcutta.

The title of the present discussion is of such a wide nature that unless we limit its scope to a certain extent, I am afraid, our labours are likely to prove unfruitful. I shall therefore limit myself to one particular aspect of the question which has been raised by the previous speaker.

Dr. Sen-Gupta has pointed out that all our behaviour is, in a way, social behaviour. But as anthropologists we are not interested in every detail of man's behaviour, even though it may be conditioned to a large extent by his social setting. From a broad point of view, we observe that man, in different societies, are actuated by similar feelings. But they do not behave in exactly the same manner under the stress of similar situations. There seem to be *customary* ways of giving vent to feelings, just as there may be customary ways of behaving when one is hungry or is in love. Each civilization seems to carry a large number of such customary patterns of behaviour. And it is in these crystallized forms of behaviour that we are interested as students of cultural anthropology.

Both coal and diamond are ultimately made up of the element carbon. But they take different shapes under the stress of different historical conditions. A psychologist may feel tempted to go down to the very roots of the matter of behaviour-patterns like a chemist; he feels satisfied only when he has succeeded in reducing everything to ultimate psycho-physical responses to particular stimuli responses. But an anthropologist is more like a geologist in this respect; for he is more interested in discovering the special historical, social and geographical conditions under which particular forms of behaviour take a concrete shape; a shape which is later on transmitted from one generation of men to another by custom and by well-directed education.

This is so far as social behaviour is concerned. With regard to conflict, I am not sure if Prof. Chattopadhyay refers to conflicts within the individual mind or to cultural conflicts in the social sphere. In course of our anthropological investigations, we often come across cases in which two civilizations come in contact with one another. Each is, in every case, characterized by different patterns of behaviour and by a different set of social values. Under such circumstances, many types of cultural syntheses may come into being sometime after the initial impact. During the 19th century in Bengal, there were decided movements towards Europeanization as well as towards a revival of Hindu culture.

Half-way houses of culture were also built. Placed under this situation, we find different individuals or different social groups displaying different kinds of loyalties. Sometimes an individual may be torn between two conflicting loyalties; he may thus be placed under a condition of mental conflict. Although, as anthropologists, we are not very much concerned with these various loyalties displayed by the individual or a particular group, we are so often confronted by this phenomenon in course of our cultural historical analysis that some kind of explanation is occasionally forced upon us.

From a very cursory study of such phenomena, it has suggested itself to us that these loyalties spring from hidden psychological sources within the individual. Men love power, and in the selection of cultural traits, we find *a predilection for those particular traits as are associated with a politically more powerful group.*

Thus, the selectiveness displayed by individuals or groups in course of cultural contacts has, in the last resort, to be referred to the psychology of the individual. The ultimate explanation of many cultural facts turns out, in this way, to be psychological.

7. Mr. Pars Ram, Lahore.

Let us designate the life of a stable social group as the *reality plane* of that group and see what happens to it in a state of social disorganization. Economic upheaval and tensions created by the new situations block the normal reality plane of the group as a result of which the phantasy plane of the group is reactivated. Hence a period of social disorganization is a period of new ideologies and religious movements which absorb the anxieties and insecurities of a vast number of individuals.

These new ideologies bring a state of stability and give a new faith to the people. Thus individual sufferings are covered by a mass neuroses.

XXIX. SYMBOLISM AND RITUALS.

(Sections of Psychology and Anthropology.)

Dr. I. Latif, Lahore, presided.

1. Mr. H. P. Maiti, Calcutta.

The importance of ritual for the evolution of human culture is very great. It lies at the root of the origin of Religion and Arts. In their attempts to explain the origin of ritual, anthropologists have used in the past psychological concepts that refer mostly to the conscious processes of the human mind. Primitive ritual, however, is spontaneous and arises out of an unconscious demand of human nature.

Certain repetitive acts of obsession neurotics resemble in all essentials the ceremonial rituals of religious life. In course of psychoanalysis we come to know the psychological conditions of origin of such individual 'rituals'. In the life of individual children also we can directly observe the growth of similar ritualistic ceremonies. Rituals arise out of a condition of unconscious emotional conflict and serve to discharge economically emotional energy which otherwise would have come in a massive form and produced anxiety.

To one who practises ritual it is endowed with mysterious powers and significance. The factor of symbolism present in ritual makes this possible. Symbolism in other words provides the means by which ritual

is able to bind and condense the expression of emotional energy through certain definite acts and processes and thereby secure relief from anxiety. In order to understand this relation it is necessary to determine the exact meaning of symbolism appropriate for the context of the present discussion.

In its widest connotation symbol is anything that stands for some other object or experience with which it is not directly and naturally associated. A word is the symbol of the object it means in this sense. According to a second definition symbol is the representation in our mind of some sexual object or act by the idea of an ordinary object or act. Dream affords examples of this type of symbolism. There is a third meaning of symbolism in which an unconscious element not necessarily sexual only in import is represented by some unconnected act or idea. Many of the mental symptoms of hysteria, obsession neuroses or schizophrenia are symbolic representations in this sense.

The first meaning of symbolism would be too wide, and the second too narrow in the context of the present discussion. Some elements of rituals may have sexual significance but it is doubtful if all the symbolic elements of it represent sexual ideas in the unconscious. Most of them serve as substitutes of other ideas which on account of intense emotional accompaniments cannot have direct expression. There is not only economy of representation but also economy in the discharge of emotional energy investing a group of unconscious ideas in ritualistic symbols.

To the primitive mind the symbols in rituals have direct and automatic powers. The cultured mind tries to justify these powers through 'spiritual' interpretations. It is evident that, as in the case of symptoms of mental diseases, the ritualistic symbols of unconscious origin should be supplemented by rationalizations. Hence it would be necessary to distinguish between a conscious and an unconscious symbolism in ritual. Connected with this question is that of changes in ritualistic symbols with progress of civilization. The ritual itself is more stable than its symbolic elements which undergo, though very slowly, change of form with change of geographical and social conditions of life.

When the group of ideas of the unconscious mind underlying the ritual are brought under intellectual judgment and, what is more important, the blocked emotional energy investing them is discharged otherwise, rituals tend to lose their magic influence over the human mind. Philosophic forms of religion and arts provide partial alternatives to rigid rituals.

2. Prof. K. P. Chattopadhyay, Calcutta.

Symbolism in ritual may grow up on the basis of various forces. (1) A powerful social urge which cannot find open expression due to social conflict, internal or external, may be symbolized in ritual. Thus in marriage, in a patri-local society, the relations of the bride, especially the women folk, desire but cannot openly try to secure dominance of the girl after marriage, over her spouse. Symbols take the place of actualities in consequence. In Arab society, a girl at marriage rides a yoke on a wooden horse. This rite symbolically represents the wish fulfilment noted. A Hindu woman in Bengal similarly ties the hands of her son-in-law with thread and asks him to behave like a docile heart of burden. (2) A different origin of ritual, apparently symbolic, is to be found in vestigial survival of older customs exemplifying satisfaction of a former social force. Thus a Santal in the reserved areas, who has lost his belief in the older faith, largely under the influence of Christian missions, now practises burial instead of cremation. Nevertheless, some days after the ceremony he digs a small hole and fills it with water, calls it 'Nai' or river and sprinkles the water on his head. He also puts in it a bit of hair or nail which he has cut off from the dead body before burial. He is in fact symbolically performing the water disposal of the bones of the dead

which is the orthodox mode of final disposal, following cremation. (3) A third source of symbolism is functional. In Santal society the village acts as one whole in social matters. There is a powerful belief also in the unity of the dead and the living. The Nacke-Nanghi, the sacred headman represents this unity and comes from the family of the founder who is in a sense the creator of the group in question. In all ritual this unity of the village and the dead is expressed symbolically, the symbol in this case being a living person. The union of the deceased with the ancestors is also symbolically represented as a marriage rite in the final death ceremonies. It is also a fulfilment of a powerful social urge proceeding from the same beliefs.

3. Dr. Rabindranath Ghosh, Calcutta.

From the psychoanalytic study of human individuals, we find that the rituals ensure the individual an economy of his mental energy and a security against his internal dangers. The rituals demand as a price the restriction of the individual's ego and ego-activities. Similarly, in the case of social rituals, that is, of those common rituals as practised by the members of the same society, we find in operation those characteristics as mentioned above. Society is composed of individuals who are bound together by such psychological mechanisms as identification, projection, introjection, etc.

Almost all rituals express themselves through some symbolic actions and symbolic modes of behaviour. Hence symbolization is another unconscious mechanism, operating in the building up of a ritual.

As in the case of an individual so in the case of a society, all rituals need not be considered as symptoms of mental abnormalities. Those rituals which are very far removed from the reality and which fail to cope with the individual's or society's attempt at adaptations of reality need be considered as pathological. Hence every ritual has the possibility of becoming a pathological manifestation under certain conditions of practical life.

4. Dr. N. N. Sen-Gupta, Lucknow.

(1) *Symbol in the narrow sense.*

A symbol is a specified sensory content, variable to the least degree, and associated with (i) another well-defined sensory impression, or (ii) a set of meanings. The letters of the alphabet are symbols in the first of these senses. Certain mathematical and logical and chemical symbols instance the second point. Symbols can be substituted for experiences they are associated with.

(2) *Symbol in a wider sense.*

A symbol is any perceptual object, visual, verbal and behavioural which may lead to the evocation of meanings, emotions and reactions. An instance of a visual symbol is a flag. That of a verbal symbol is any party slogan, or mystic formula such as *Om*. A behavioural symbol is instanced by various *gestures*, those of submission, friendship or enmity.

(3) *The origin and social character of Symbols.*

(i) Symbols often originate in some incident in the racial history. It is carried forward by *tradition* and thus becomes the common property of the group. The large mass of tradition gives it a varied connotation, some of which may drop off and the others *fixed* through the selection

(*a*) by historical exigencies. The *cross* has a complex meaning for one belonging to the Christian tradition. But it frequently means sanctity and divine power. (*b*) Sometimes, however, a new meaning may be given to a symbol by a voluntary act. For instance, the Swastika has shed its Vedic significance and has become the symbol of a political party that claims to carry forward the Aryan tradition.

(ii) Symbols are sometimes adopted in a pure arbitrary manner. President Theodore Roosevelt had chosen as the symbol of his Independent Party the *bull moose*. The choice of the symbol was more or less arbitrary. The symbol of the Democratic Party was the donkey and that of the Republican Party the elephant. Another animal that would indicate vigour and combativeness had to be selected. There was no reason why some other vigorous animal such as a horse, a tiger or a mythical dragon could not have been chosen.

(iii) Symbols sometimes are chosen because of their capacity to represent the various items of facts they represent. The stars in the U.S.A. flag represent the States. The tricolor of France represents the verbal symbol of Liberty, Equality and Fraternity which in its turn represent a social and political order.

(iv) Symbols are sometimes selected on account of their emotional connotation. Lion as a political symbol evokes emotion. *John Bull* and *Uncle Sam* are symbols of certain qualities and attitudes. The use of the *Goddess Durga* as the symbol of the motherland had by Bankim Chandra Chatterjee on the other hand an emotional meaning as well as a meaning discussed under (iii). This last, too, was calculated to elicit an emotional response.

(v) Symbols are sometimes employed to keep the meaning secret. The magic-signs, the *Sandhyā-bhasha* or the twilight language of the Tantric tradition, and the symbols of various secret societies are the instances in point.

All these symbols have an impersonal significance because of their historical origin or because of their setting in the group life.

(4) *Personal Symbols.*

It is necessary to point out a class of symbols which possess a significance only for an individual. These are represented by the fetishes and symbols of the neurotic carrying a reference to the unconscious. These appear to be devoid of sense for observers; but they possess a deep significance for the person concerned.

(5) *Personal Symbolic acts.*

Certain neurotic acts can only be explained as symbolic in character. The various kinds of *stereotyped* actions are said to belong to this category. A person I know ties a knot in his dhoti whenever he happens to wear a new one. It is almost certain that the act stands for tying the nuptial knot. Many such symbolic acts are found as instances of neurotic behaviour. All of these possess a deep personal meaning.

(6) *The Behavioural Symbols.*

There are certain behaviour-symbols which possess meaning for the group as a whole. The Nazi-salute has become a symbol for an entire nation. The Guy Fawkes' Celebration is another instance of symbolic behaviour. So is the observance of the Independence Day in this country nowadays.

Symbolic *acts* and *behaviour* are symbols in the sense defined above. These have private and public significance respectively. The latter, however, may become translated into the former. The Nazi may feel

that the salute has a special meaning for himself. The items of the programme of the Independence Day may have a special meaning for certain persons.

(7) *Compulsions.*

Certain acts apparently meaningless, assume for certain persons the character of a compulsion. The basis of this fact is said to be in the unconscious. Hence, these compulsive acts are *symbolic.*

(8) *Rituals: Their nature.*

(i) Rituals are symbolic acts. (ii) They take place in the context of an ideology, mainly religious. (iii) They possess both a public and a private significance. (iv) They sometimes assume a compulsive character. Hence, they have an unconscious meaning.

(9) *Types of ritual.*

(i) Some of them are the *remnants* of more complex forms of religious behaviour, e.g. Tarpana. Such fragments may be of a two-fold significance: (*a*) In regard to the material employed as in the offering of *Arghya*, *Bhūmi-dāna*, etc. (*b*) In regard to behaviour as in *Karanyāsa*.

(ii) Abbreviation of a more complex behaviour.

(iii) A part behaviour representing the whole.

(iv) A new behaviour pattern representing another, e.g. Mantra-rituals.

(10) *Ritual in each of these senses is a symbolic behaviour.*

It is, however, not always a compulsion behaviour.

It may be described as *necessary* behaviour rather than as a compulsion-behaviour. The difference is as follows: In *compulsion-behaviour* the whole chain of responses acquire a compulsory character. In *necessary-behaviour* once the first step is taken, the rest become inevitable. Violation of the order, omissions and interpolations implicate penalties.

(11) This suggests that there are two types of rituals: (i) Some of them possess the character of true compulsion acts. These are found in the great emphasis laid by some people on ritual acts. (ii) Reinstatement of a past, ideal or mythical situation. The former instances of ritual refer to personal motives, unconscious factors. The latter refer to ethnic and social psychological factors.

5. DR. A. AIYAPPAN, Madras.

Ritual is absolutely normal behaviour in so far as normality can be judged by the anthropologist. Explanations of ritual in terms of abnormal psychology are not helpful in field work among backward tribes. While the anthropologist would leave the psychological aspects of ritual to be interpreted by the professional psychologist, he expects from the latter certain directions as to what he should look for in ritual situations in order to make the anthropologists' data useful for psychology. The first question, therefore, is: Is there any real difference between ritual actions and other kinds of behaviour? If the answer is in the positive, a clear formulation of it in non-controversial terms is bound to be of great use to field-workers in anthropology.

XXX. THE PLACE OF PSYCHOLOGY IN THE FIELD OF MEDICINE.

(*Sections of Psychology, and Medical and Veterinary Research.*)

Mr. A. C. Ukil, Calcutta, presided.

1. Dr. I. Latif, Lahore.

Ignorance or neglect of Psychology on the part of the general medical profession is mainly due to two causes: (*a*) a strong bias in favour of physical aetiology for all human disorders, and (*b*) the common belief that the use of psychological medicine must be confined to the patients resident in mental hospitals. Mental and bodily factors often fuse in the aetiology of disease and disorder. Every ailment has its psychological aspect. Hence a system of treatment which excludes the consideration of psychological factors is bound to be limited in its therapeutic results. But *functional* disturbances of the individual, as a rule, defy physical therapy. They are only amenable to psychotherapeutic treatment. The rest of the paper treats of certain cases of functional disorders with a view to illustrate the efficacy of psychological medicine.

2. Dr. C. Saha, Calcutta.

Present position of Psychology is like a step-child of Medicine as evidenced from literature, medical curriculum and textbooks of Medicine.

There is definite connection between the body and the mind.

Four groups of mental disturbances require psychological approach for their complete understanding.

(*a*) Definite psychoneurotic disorders.
(*b*) Functional disturbances.
(*c*) Some diseases of doubtful origin.
(*d*) Organic diseases with mental symptoms.

Organic diseases at the stage of development may be mistaken as 'Functional' if the mind is not examined.

A suggestion is made for the teaching of Psychology with Medicine.

3. Mr. H. P. Maiti, Calcutta.

A. Disease is fundamentally a functional concept. The distinction between Psychology and Physiology is based on historical reasons and on schematic necessity. But the Physical and Mental diseases are inter-related, the nature of the inter-relationship varying in different cases. Hence Psychology should find its proper place in Medicine.

Scientific study of Psychology should on the practical side lead to better adjustment between man and the conditions and ideals of his life. One aspect of this process of adjustment is related to the subject of medicine. Hence Psychological Medicine should be one of the branches of applied Psychology.

B. We are having at present a new outlook about relation of Psychology to Medicine. Certain difficulties shall have to be overcome if it is really to work.

The relative advantages and disadvantages of the physician and the psychologist at present regarding study and treatment of mental diseases. They should serve humanity in mutual co-operation and with mutual help.

4. DR. S. N. BANERJEE, Calcutta.

(1) Experimental methods on impersonal factors have added to the knowledge of Psychiatrist, but there is a danger of neglecting the wider aspect of the human life.

(2) Sigmund Freud revealed the importance of unconscious factors in the structure of personality.

(3) Psychiatry has its own special problems, which has to be dealt with by appropriate methods.

(4) Interest of the Psychiatrist was supplemented by the interest in studying dynamic problems of the individual case. It took up disorder of personality as its field.

(5) It sought in the individual case, to attribute its due failure to each of many component factors, biochemical, physiological, psychological and environment.

5. MR. M. N. BANERJI, Calcutta.

The relation of Psychology with the science of medicine is very intimate. Every symptom has its repercusions on the mind, and is only properly recognized by one having an understanding of both Psychology and Pathology. The researches of psycho-analysts have brought home to the psychiatrists the supreme importance of the training in psychology for the understanding of mental symptoms and also have demonstrated the efficiency of the psycho-analytic method of approach to the treatment of most of the types of neurosis and certain forms of psychosis. More recently psycho-analytical treatment has also been found very useful in some forms of apparently physical symptoms like certain types of cutaneous affections, certain forms of asthma, duodenal and peptic ulcers and the blood pressure.

In two recent articles published in the *Psycho-analytic Quarterly,* Part II, 1940, the influence of psycho-analysis on medicine has been lucidly dealt with. Dr. Smith Jelliffe, the celebrated author of the famous big compendium on nervous and mental diseases, has written a very short paper on the influence of psycho-analysis on neurology. Dr. Jelliffe writes, 'Neurology, in its narrower sense, remained faithful to its friend of old—Cartesian psychology. Psycho-analysis came as a sword to cleave this ancient coalition and to give new life to an enfranchised body of neurology. ....To me psycho-analysis has liberated neurology from some of its invested and fixed patterns of thinking. It has rendered vital much that was static and formal within the neurological frame of reference and has made comprehensible and alive much that neurology was content to codify'. Dr. Paul Schilder has chosen as the subject of his learned paper the influence of psycho-analysis on psychiatry. Dr. Glen Myers has contributed an article on Freud's influence on psychiatry in America. Psycho-analysis is nothing but the psychology of the unconscious and the deeper part of the mind.

I do not consider it out of place to draw the attention of the audience to the practical views which swayed the field of the topic of this symposium in India, until the advent of western theories on the subject, both as regards the causation of diseases and also the methods of their treatment. According to ancient Indian medical writers Charaka and Susruta psychological causes were held to be the principal factors for the development of mental symptoms and diseases, and contributory accessory factors of some of the physical disorders; while various psychological methods were restored to for the treatment of almost all disorders both of the mind and body.

It is well known that some of the basic principles of Hindu culture and of philosophy have a strong psychological foundation and they are imbued with a faith in the transmigration of the soul and the law of KARMA. The works on Smritis and some of the Tantras speak of certain

types of bad deeds done in the present or past lives as the ultimate cause of certain specific diseases. They elaborated various forms of expiations for the curing of such maladies. There was abiding faith in the hostile influences of planets and superhuman intelligent entities. There were therefore devised various methods of propitiating, mitigating or undoing such influences by magic, charms, spells, amulets, bangles, suggestions, pilgrimages, fastings and sastyayanas. In fact, the Atharva Veda, Smritis and the Tantras are replete with such countless remedial measures correlated with various mantras and incantations. The Atharva Veda has embodied 63 charms, spells and mantras for the treatment of various bodily and mental ailments. The Prayaschitta Viveka of Sulapani contains amongst other things prescriptions of expiations for various disorders and physical signs of the body. It must never be understood that the practical application of processes as distinct from physiological medicine for the alleviation of diseases in the field of medical treatment is a matter of past. In fact, these ideas were so ingrained in the Hindu culture that works on medicine, though fully alive to the proper scientific aspect of things, yet pandering to local customs and beliefs, recognize the importance of such processes and classify them under the head of Daiva medicine out of three types of medicine, the other two being Yukti Vyapasraya, युक्ति व्यपाश्रय (i.e. founded on logical principles) and Sattvabajaya, सत्वावजय (i.e. the rectification of the two gunas Rajah and Tamah by the withdrawal of mind from alluring interests and aims prejudicial to the well-being of the patient). According to the Charaka the Daiva group comprises the following (Ch. XI, Sutra Sthanam):—(1) Mantra—mystic sound formulae, (2) Ousadhi—herbs, (3) Ratna-Dharana—wearing of gems, (4) Mangalik Karyya—auspices rituals, (5) Puja—propitiation of deities, (6) Upahara—presents and gifts to deities, (7) Homa—sacrifice in fire, (8) Niyama—observance of vows, (9) Prayaschitta—expiation, (10) Upavasa—fastings, (11) Veda-Patha—chanting of the Vedas, (12) Pranipata—obeisance to deities and saintly persons, (13) Thirtha Yatra—pilgrimages to special deities and places of cures. It may be pointed out that all these exercised a beneficial influence upon the mind of the patient.

The great ancient Indian medical works of the Atreya and the Dhvantara schools, whose origins are traced by competent European scholars to the 6th century B.C., contain in them chapters on principles of general and physiological psychology for imparting necessary working knowledge of psychology to students with a view to facilitate their understanding of the significance of symptoms in the schemes of humoral theory and the modes of the treatment of mental diseases. The Atreya school contains in addition chapters on psychological medicine and goes further to stress the psychological factors even in the causation of physical symptoms.

The Charaka Samhita in Sutra Sthanam Ch. I, discussing the general principle of the causation of diseases, says

कालबुद्धीन्द्रियार्थानां योगो मिथ्या न चाति च
द्वयाश्रयाणाम् व्याधीनां त्रिविधो हेतुसंग्रहः

Mitthya or false or contradictory contact, want of contact and excessive contact of time, Buddhi (i.e. understanding, endurance and memory) and the aims of the sense organs are the principal causes of maladies which affect the two, i.e. the body and mind. I shall not here enter into an exposition of this passage which contains in a pithy sentence the etcology of disease. In another passage

वायुः पित्तम् कफश्चोक्तः शारीरो दोषसंग्रहः ।
मानसः पुनरोद्दिष्टो रजः तम एव च ॥

प्रशाम्यत्यौषधैः पूर्व्वो दैवयुक्तिव्यपाश्रयैः ।

मानसो ज्ञान-विज्ञान-धैर्य्य-स्मृति-समाधिभिः ॥

Bodily ailments are caused by Wind (Vayu), Bile (Pitta) and Phlegm (Kapha)—rather by a loss of their balance. Mental ailments are caused by the two Gunas, Rajah and Tamah, overtaking the Sattva. Of the two the first one, i.e. bodily diseases are alleviated by medicines belonging to Daiva and Yukti Vyapasraya groups while mental diseases are cured by (1) Adhyatma Jnana—knowledge concerning the working of the body and specially mind, (2) Vijnana, i.e. understanding and knowledge of scientific texts, (3) Patience, (4) Memory, and (5) Samadhi—the process of total abstraction from all disturbing elements. These have all a psychological background.

This is not the time or place to discuss the principles of the Gunas and the Humoral theory. A short account of my exposition has been printed in the *American Journal of Psychology* (Jub. Vol.).

According to the Roganika Vimana, Chapter 6 of Vimana Sthanam, Rajah and Tamah are the two Doshas, defects or deviations of mind, From them spring sex impulses, anger, avarice, infatuation, jealousy, wound or hurt to one's sense of pride, insolence, sorrow, anxiety, fear and joy (K 322 VI).

We find a little elaboration of the causes of the mental diseases and their treatment in Sutra Sthana, Ch. XI.

मानसः पुनरिष्टस्यालाभाल्लाभाच्चानिष्टस्योपजायते ।

Mental diseases are caused by non-attainment of things sought for and by the attainment of things thought to be disagreeable, troublesome, never sought for.

मानसं प्रतिभैषज्यं त्रिवर्गस्यान्ववेक्षणं ।

तद्विद्यसेवाविज्ञानमात्मादीनाञ्च सर्व्वशः । इति ।

This passage is expounded as follows by the celebrated Chakrapani, 'The attainment or non-attainment of Dharma (religious merit), Artha (wealth) and Kama or desires cause happiness or misery in man. Ways and means for the conservation of the above three should be resorted to for counteracting mental diseases. Effects should be made to associate with people versed in the knowledge of these matters and who are old, in order to understand oneself including location, time, family, power, energy. Knowledge of these is curative of mental disorders. The above methods are also applicable in bodily ailments.

In the 7th and 8th chapters of the Nidana Sthana dealing with the diverse causes of the various forms of mental diseases, insanity and epilepsy—the author finally refutes the agency of the Devas, Gandharbhas, Pisachas, Rakshasas, planetary influences, etc. We come across the following passages in the 7th chapter:

नैव देवा न गन्धर्वा न पिशाचा न राक्षसाः ।

न चान्ये स्वयमक्लिष्टमुपक्लिश्नन्ति मानवं ॥

ये त्वेनमनुवर्त्तन्ते क्लिश्यमानं स्वकर्म्मणा ।

न तन्निमित्तः क्लेशोऽसौ न ह्यस्ति कृतकृत्यता ॥

Taking the sane view of things, the texts finally assert the paramount importance of one's own deeds of a particular type which are technically known as Prajnaparadha. The word Prajnaparadha connotes a sense

of guilt for the wilful transgression of certain accepted ideals of thought and conduct either by actual deed, thought or speech.

'तस्य निमित्तं प्रज्ञापराध एवेति भगवान् पुनर्व्वसुरात्रेय उवाच'—

प्रज्ञापराधात् सम्प्राप्ते व्याधौ कर्म्मज आत्मनः ।

नाभिशंसेत् बुधो देवान्न पितॄन्नापि राक्षसान् ॥

According to the Charaka the causes as well as the Humoral principles affected are identical in both insanity and epilepsy. Therefore, it will not be out of place to draw the attention to the class of persons who have been recognized to be prone to epilepsy. They have been described in the beginning of the 8th chapter. They are practically people depressed with a sense of guilt Prajnaparadha and subject to great emotional disturbances due to the ruffling of the two Gunas, Rajah and Tamah, therefore suffering from fits of strong sexual urges, rage, fear, avarice, selfishness, joy, sorrow or anxiety, or in short being temperamentally unstable and introspective.

In mental disorders and epilepsy it is the humour of Wind (Bayu) that shows excessive activity; therefore the following remedial processes are applicable. They are described towards the last part of the 6th chapter of Vimana Sthana. They are (1) annointing with oil and fomentation, (2) mild correctives, (3) tepid food containing fats, oils, sour and salt, (4) Upanaha—tepid unguent containing oil, salt and substances of acid nature, (5) Upabestana—wrapping up with wet cloth, violently annointing, sprinkling the body with water, immersion baths, kneading, frightening, (6) Bismapan, i.e. causing surprise, (7) Bismaran—causing to forget something; application of wines, asavas, appetizers and digestives, fats and oils cooked hundred or thousand times, containing ingredients which are alleviative of the wind and are purgatives and various types of enema.

The Charaka (Chikitsa Sthana, Ch. 14) recommends the following processes for the treatment of mental diseases after trials have been given to various types of medicinal applications. These processes mainly produce strong affective reactions and were calculated to bring the patients to their senses awakening them to make contacts with realities of life. Sympathy suggestion, persuasion, surprise and shock therapy were the diverse methods resorted to. (1) Sometimes if the patient is kept in a place free from breeze after giving him a sumptuous meal containing ghee and meat he recovers his senses and memory. (2) Friends may speak to the patient talking about religious matters and giving him sympathetic advice regarding attainment and preservation of wealth. (3) He may be told about the loss or destruction of a very cherished thing. (4) He may be shown curious or terrible things. (5) He may be annointed with mustard oil, then kept in the sun resting on the back, hands and feet tied. (6) He may be touched with hot iron, oil or water or with Alkushi fruits which are very irritating. (7) He may be caned and then kept in a solitary cell. These processes sometimes remove aberrations of mind. (8) The patient may be frightened by means of the exhibition of a snake whose fangs have already been removed, a tamed lion, an elephant, cutting instruments, a thief or by enemies. (9) The police officers after taking previous permission from the king may take a patient outside the town, after binding him and then severely frighten and beat him.

Afflictions of body and sorrow excite fear of life and fear of death sometimes is able to bring round a patient by producing a binding influence on the mind. Those who have gone off their mind owing to the loss of a dear thing may be given a similar thing or may be consoled to peace by sympathy.

We bring to a close our account of mental disease in Hindu Medicine by drawing attention to the following principle. Mental disorders born

of sex urge, sorrow, fear, hate or anger, joy and avarice or selfishness should be treated by the excitement of contradictory emotions. Thus try to overcome the sexual by development of sorrow. When the insanity is caused by sorrow it may be counteracted by the kindling of sex urge. Those with fear as the root cause may be excited to anger; those with a basic anger may be depressed by a suitable excitement of fear; those who have gone mad of joy, may be brought to their senses by excitement of avarice or selfishness; while those cases of insanity where avarice or selfishness is the root cause may be treated by processes productive of joy.

It will be seen that ancient Indian writers on general medicine when they hit upon the theory of Prajnaparadha—the sense of guilt as the prime cause of mental disorders—came very near to the basic findings of psycho-analysts in the causation of mental symptoms. The sense of guilt was clearly there but the innate urge on the part of the patient for expiation, suffering and will to illness is not clearly recognized. There is no hit on the unconscious factors and the sexual theory though there are passages suggestive of reviving the memory or depressing it. Ancient Indian medical writers whole-heartedly accepted the methods of expiation elaborated by the Smritikaras. I have elsewhere discussed the Indian Psychology of Expiation, the basic principle of which is a clean breast confession before Smartas or priests of one's own transgressions and guilts and the acceptance of and undergoing bodily punishments and fines and the PRANAYAMA. If an expiation is not sufficient to remove the symptoms the confessions have got to be repeated in the presence of 3, 7 or 21 persons until a cure is effected.

It appears to me rather axiomatic that a training in psychology should form an indispensable portion of the curriculum on medicine with a strong emphasis on the psychology of the unconscious for those who want to specialize in neurology and mental diseases. Some time ago the Indian Psycho-analytical Society tried to impress upon the necessity of psychological training for medical graduates and endeavoured for a recognition of this fact by the Calcutta University with a view to changing the regulation for an inclusion of psychology and psycho-analysis in the medical curriculum. Somehow or other the movement did not make much headway.

In conclusion, I would beg this joint meeting of the Psychology and Medical Sections of the Science Congress to put on record that it is their emphatic opinion that psychology and psycho-analysis should form part of the medical curriculum in the Universities and the authorities of the Science Congress be urged to take up the matter and urge the various Universities for the recognition of psychology and psycho-analysis in the medical curriculum.

6. MR. N. DE, Calcutta.

Psychosomatic Relations.

Until very recently the medical profession of the modern times have taken no notice of the psychological aspect of the patient. Specialization in the field of modern medicine has further narrowed the viewpoint of the practitioner only to one organ in many cases. Patients are also being accustomed to such specialization and as a result we often find a patient who comes to his physician and says, 'Doctor, I have come to you for my heart, my lungs, my brain, my bowels, etc.' Patients and unfortunately many physicians of modern times forget that the whole body and the mind act as a unitary whole.

But, that the body cannot be treated apart from the mind was realized even in the olden times. Prof. Banerji has told you about the importance laid on psychology in Ayurvedic Medicine. During the Greek period

Socrates the wise taught the physicians of his time 'Let no one persuade you to cure the head until he has first given you his soul to be cured, for this is the great error of our day in the treatment of the human body that the physician separates the soul from the body'.

I cite below a few convincing examples of the influence of the mind on the body and of the body on the mind under normal and abnormal conditions:

(1) Effect of the mind on the body under normal conditions.—Of two sisters, aged 15 and 18, the elder was married and in the family way. As her abdomen was growing in size the younger unmarried sister seemed to take more interest in the coming child than the prospective mother herself. Whenever she would lie on her abdomen or anyhow exert pressure on the womb, the younger sister would say, 'Sister, what do you mean? Do you want to kill your child?' Now, when the child was born milk appeared at its mother's breast and lo and behold, breasts of the younger sister also became full of milk, so much so that it began to flow out and the flow had to be stopped by treatment.

(2) Effect of diseased mind on the body.—Schizophrenia is said to be a purely mental disease but many of the schizophrenics in catatonic stage show cyanosis and swelling of dependent parts due to stagnation of blood and fluids in them and what is more important, defective ventilation in the lungs of these catatonics predisposes to tuberculosis and more than half of such patients die of tuberculosis.

Physical manifestations of hysteria and the various visceral neuroses due to purely mental trouble are well known. Davies and Wilson (*Lancet*, 1939, ii, 723) have shown that mental troubles were responsible for definite organic manifestations like haemorrhage and perforation from gastric and duodenal ulcers. Events capable of producing unusual emotional tension were found to precede haematemesis and perforation in 63 out of 75 patients These events preceded the haemorrhage or perforation by a few days and usually related to increase of responsibility, financial difficulty and illness or trouble in the family.

(3) Effect of normal physical phenomena on the mind.—A young man of 30 had by chance seen a beautiful young woman in absolutely naked state. From that time he was so much obsessed with that picture that he could not remove it even for a moment from his mind's eye. When it had persisted for several days he came to me for treatment. I gave him sedative drugs but they had practically no effect—he was seeing the vision all the while he was awake. On the 10th night after the incident he had seminal emission and with the relief of tension in the seminal vescicles the mind was relieved of the obsessive image.

(4) Effect of diseased body on the mind.—Mental depression from long continued physical diseases at times leading on to suicide are well known. Loss of recent memories without any loss of older ones during convalescence from typhoid fever is also known to many physicians. The following is an example of absolute alteration of personality after an attack of encephalitis lethargica. A boy, who was perfectly docile and well-behaved, suffered from the disease when he was 10. He became so mischievous after the attack that it was difficult to manage him at home and at school. He would lie, steal, tease other boys, make sexual advances to young girls and to grown up women and practise a thousand other naughty and foolish tricks against anybody and everybody without any regard for age, position or relation.

(5) Effect on the mind of drugs, operations and other therapeutic measures used in general medicine, surgery and gynaecology.—The drugs used in general medicine have marked effect on the mind of the individual taking them, but unfortunately these are not taken into account when they are used for their somatic action. Benzedrine sulph is often used for its mild adrenalin effect and more commonly for its drying effect on the nasal mucous membrane. On the mental aspect, in 10–20 mg. doses it produces exhilaration and increase in energy and power of concentration

and definite increase in intelligence score. Bigger doses produce confusion and disorientation. One student who used the drug before an examination filled the pages of his examination paper by writing his own name repeatedly in them feeling confident that he was writing a good paper, though he was not suffering from any marked somatic poisonous effect of the drug. Sodium benzoate in ordinary doses retards mental process. Mescaline when used by mouth or by injection perverts special senses. Things taste, smell, look and hear different. Gradually the feeling of the body vanishes; position of the limbs cannot be localized. Drugs of the belladonna group are often used for relieving colic, etc. I was called in to see a patient who had been given one injection of hyoscine hydrobrom gr. 1/130 and two tablets gr. 1/75 each of the same drug by mouth and I found him absolutely mad. Barbiturates are the most commonly used hypnotics and anti-convulsants. When they are used for a long time, along with some somatic toxic effects are found disorientation, narrowing of horizon of attention, hypomanic picture, euphoria like state, hallucinations, delusions, confusion and incessant incoherent talk. Bromides are often continued for months or even years for epilepsy. There are many commonly used patent medicines which contain bromides in large doses. The result of such continued use of bromides are visual and auditory hallucinations and depression with suicidal tendencies. This sort of bromide psychosis is so common nowadays that in most up-to-date mental hospitals it is a routine practice to estimate the quantity of bromides in blood and urine of every patient on admission, in order to exclude this. Opium, cocain, alcohol and chloroform habits are usually acquired after medicinal use of these drugs. The mental symptoms of these drug habits are too well known to require any description.

Surgical and gynaecological operations which result in permanent defect, debility, deformity or disability, e.g. amputation of a limb, ankylosis of a joint, enucleation of an eye, chopping off of an ear or the nose or removal of the testes, ovaries or the uterus have mental repercussions much more severe than the operators usually think of.

The above are only a few of thousands of instances of psychosomatic relation with which the general practitioner must be conversant in order to be able to treat his patients efficiently. I do not mean that every physician should be a psychiatrist but I expect them at least to be psychiatrically minded. Inclusion of psychiatry in the general medical curriculum will provide better opportunities to the future medical profession to understand these psychosomatic relations.

7. Mr. Pars Ram, Lahore.

Modern psychology and psycho-analysis in particular has, no doubt, increased our understanding of the genesis of somatic diseases by bringing home to us the presence of a psychological factor in these diseases. It has not, however, developed tools by which psychological factors which exaggerate somatic symptoms can be exploited for therapeutic purposes. With the exception of a few neurosis psycho-analytical therapy cannot be made use of in treating major psychosis and chronic diseases. The medical practitioner whose primary interest lies in healing his patients is, therefore, likely to feel disappointed at the hands of modern psychology. Nor should the task of healing somatic diseases with psychological methods be taken lightly. The duration and expenses of a psychological treatment are such as very few people can afford it. Psycho-therapy is still in experimental stage for the most part. Before its concepts are properly incorporated in the current medical practice, its scope, its successes and failures as a therapy and its limitations have to be put to a rigorous experimental test under properly controlled conditions. There are obvious difficulties in such a procedure.

For the present, therefore, psycho-therapy and medicine should follow their own development. Will the introduction of psychology in the

curriculum of medical colleges in India help the physician of the future to appreciate the psychological factor in somatic diseases? The answer to this question has to be discovered after some experimentation. In my opinion training in psycho-therapy is a full time occupation and a physician has to accept it fully or not at all. Hence a course in psychology may only interfere with the training implied in the usual medical curriculum. Of course, a diploma course in psychology for the practising physician is likely to prove of value.

8. Mr. A. C. Ukil, Calcutta.

Mr. Ukil opined that want of sympathy for psychology on the part of medical men was due to want of acquaintance with the subject.

He pleaded that the psychologists might find a method of effecting quick cure, so that their help could be of practical help to the ordinary medical practitioners.

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